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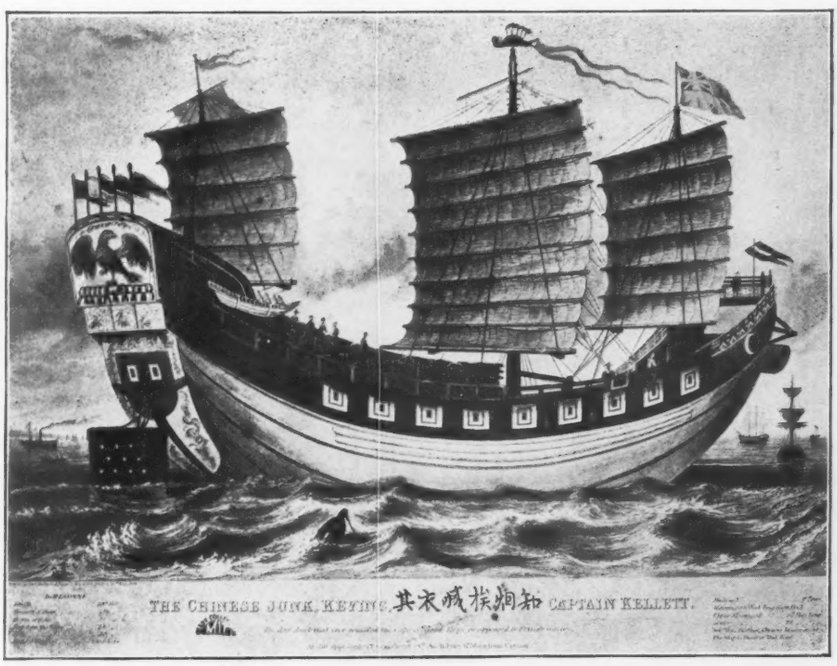
VOL. V. NO. 6

JANUARY, 1925



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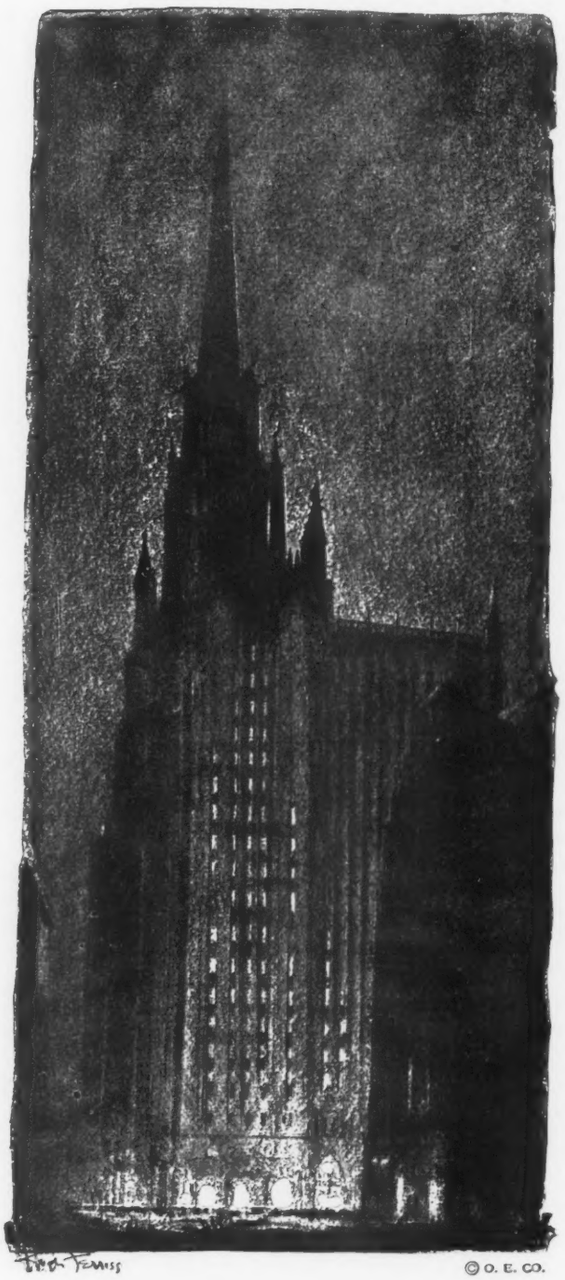

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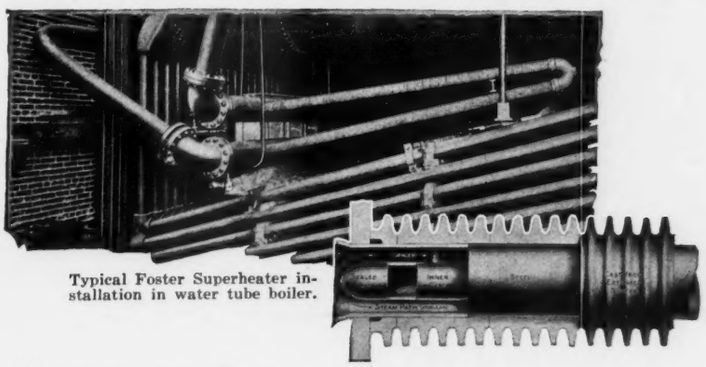

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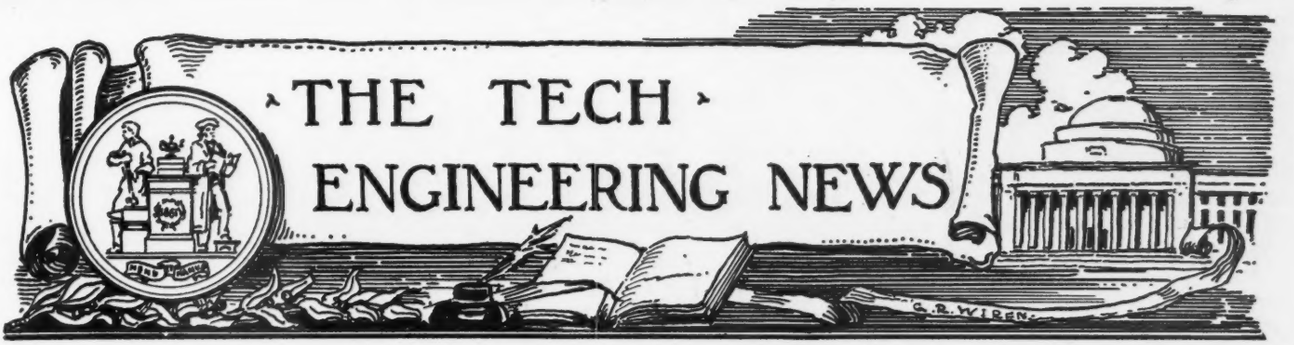

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CHARLES A. COFFIN MEDAL
FOR DISTINGUISHED CONTRIBUTION TO THE DEVELOPMENT OF ELECTRIC TRANSPORTATION FOR THE CONVENIENCE OF THE PUBLIC AND THE BENEFIT OF THE INDUSTRY AWARDED TO
NORTHERN TEXAS TRACTION COMPANY
1924

The Charles A. Coffin Medal awarded the Northern Texas Traction Company Fort Worth, Texas. George H. Clifford, Vice-President and Manager

FOR "THE MOST DISTINGUISHED SERVICE" TO A GREAT INDUSTRY

15,500,000,000 people rode on the electric railways last year. The honor of winning the Charles A. Coffin award to the company which during the year contributed most to the development of electric railway service goes to the Northern Texas Traction Company. This company has been under the executive management of Stone & Webster, Inc., for 19 years.

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V | JANUARY, 1925 | NUMBER 6

CAUSES OF FAILURE OF METAL SURFACES SHOWN BY POLARIZED LIGHT

By PAUL HEYMANS

Assistant Professor of Theoretical Physics, Massachusetts Institute of Technology

THIS article will illustrate how phenomena of double refraction, sometimes looked upon as exclusively of the domain of physics, particularly of optics, are at present used with rather surprising results for the solution of problems encountered by the mechanical and structural engineer, and by the metallurgist.

Figure 2

V-SHAPE RUPTURE

The pinion tooth has been subjected to a high radial pressure and normal torque.

We shall not dwell upon technical discussion or description of the method. We have done this in several other papers and articles published in this* and other journals. Let us rather consider in more detail one of the recent investigations which we have carried out, partly in our own laboratory at the Institute, partly in the Research Laboratory of the General Electric Company of Schenectady, N. Y., with A. L. Kimball,[1] J. L. Williamson,[2] G. R. Brophy[1] and T. H. Frost.[3]

The investigation of the causes of failures of railway motor gear pinions of apparently only endemical nature had been brought up by the Railway Motor Engineering Department of the General Electric Company.

Metallurgically, the steel appeared in excellent condition and capable of long and satisfactory life.

Structurally, the pinions seemed to be properly designed and assurance was given that they were not carrying an excessive load.

In the study of the design of the pinion, the ordinary formulae for calculation of gear teeth strength could not be considered satisfactory, but a direct stress analysis by the photo-elastic method was made, which alone could offer full reliability for the statement regarding the structural strength of the pinions under consideration.

During this direct analysis of the state of stress at the different points of the pinion, attention was soon called to the changes in the conditions of stress resulting from variations in the mounting stress of the pinion on the shaft. These pinions present a slightly tapered bore, slightly smaller than the shaft of same taper. For mounting, the pinion should be brought to the temperature of boiling water, slid on the shaft, and thus allowed to shrink on the shaft in cooling. This operation, when properly executed, secures perfect adherence on the shaft during service and easy removal of

(*Continued on page 230*)

Figure 3

HIGHLY STRESSED PINION

An example of a service fracture resulting from very high radial mounting stresses.

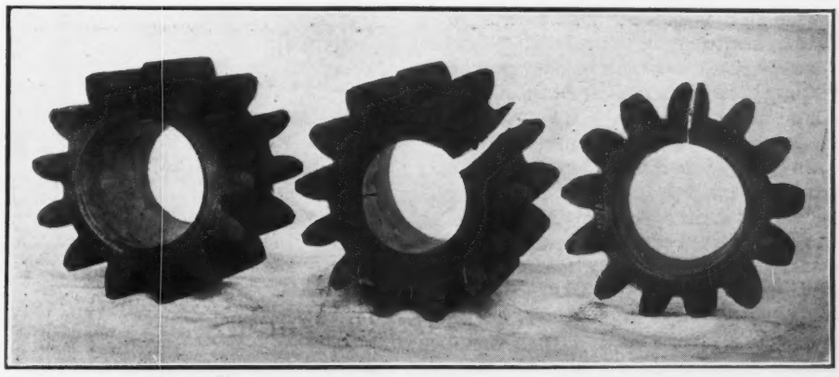


Figure 1

PINIONS RUPTURED BY BEING FORCED ON TAPERED PLUG

They present ruptures which would have been entirely unsuspected before photo elastic analysis.

* *Tech Engineering News*, June, 1922.

[1] Research Laboratory, General Electric Co., Schenectady, N. Y.

[2] Railway Motor Engineering Dept., General Electric Co., Schenectady, N. Y.

[3] Department of Physics, M. I. T.

ANALYTICAL CHEMISTRY AND THE STUDENT

By R. W. MITCHELL, '15
Instructor of Analytical Chemistry, Massachusetts Institute of Technology

SCIENCE is truth. The dictionary says, "systematized knowledge; acknowledged truths and laws, especially as demonstrated by induction, analysis or observation."

Our accumulation of facts has become so great that in the study of science, we are obliged to take most of its truths on faith. Teachers and texts bring the truths that have been found before us in a well-planned systematic manner. And so well organized is scientific instruction, that today a student can, in the short span of a college course, become master of most of the important truths, or laws, which have in their development taken centuries of observation and experiment.

Beyond being taught the known truths of science, the student is trained to have the ability to dig out and unearth for himself, the unknown truths he may come to need in his pursuit of engineering or scientific work. This is most important, for only by bringing to light the hidden facts, are obstacles overcome, improvements made, and progress achieved.

In the science of chemistry, quantitative analysis is the searching, penetrative beam which has disclosed the truths concerning the nature and composition of the manifold forms of matter of the universe. Chemistry was largely speculation, and very little science, before quantitative measurements were made.

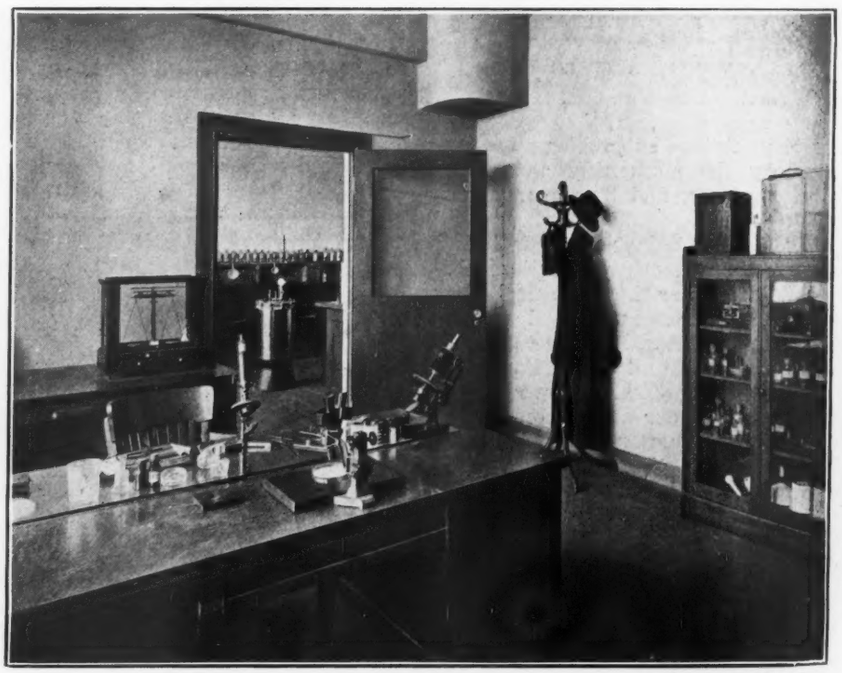
In Meyers' classical work on the "History of Chemistry," he develops, "The Special History of the Various Branches of Chemistry, from Lavoisier to the Present Day." As fits its importance, he treats analytical chemistry first, with the following introduction:

"The main problem of chemistry, the investigation of the true composition of compounds, necessarily carries along with itself the constant endeavor to elaborate and perfect the means employed for arriving at this end. Thus, since the time of Lavoisier, analytical methods which constitute the tools for the solution of this problem, have been and are being improved in a continuously increasing degree."

AN EARLY ANALYTICAL LABORATORY
Liebig's Laboratory at Giesen.

It was during the time of Lavoisier (the last half of the 18th century) that quantitative analysis made its real start, and the modern science of chemistry was first put on a firm foundation of truths. Although the quantitative method of research was followed and appreciated before Lavoisier by such men as Scheele, Boyle, Black, Cavendish and especially Bergman, still none of these investigators made use of the balance as an aid to chemical work with such definite aim and perfect conviction of its significance as he. Lavoisier first saw clearly the truth that no matter is lost during chemical reactions and he gave expression to this realization of the law of conservation of matter by indicating chemical reactions by equations.

Klaproth and Vauquelin are prominent among those who carried on the work of establishing analytical chemistry. Bergman before them, was the first to publish a system for the qualitative analysis of substances. He was the first to enunciate the principle of converting the substance to be analyzed into a convenient form of known composition, and deducing from the weight of the compound thus precipitated or otherwise obtained, that of the substance in question. The first two mentioned, as a result of their



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THE CHIEF CHEMIST'S OFFICE—THE YOUNG CHEMIST'S GOAL

care and exactitude in developing analytical processes for the investigations of minerals, discovered uranium, cerium, titanium and zirconia, and chromium and beryllia respectively. What a bag for an analyst to make! Proust also analyzed all available compounds, the results of his work leading him to a clear grasp of the law of constant proportions. His work, together with that of Richter, father of stoichiometry, foreshadowed Dalton's atomic theory. Then came Berzelius with the idea of establishing the relative weights of Dalton's atoms. This he did for many elements by an amazingly large amount of most ingenious analytical work. Many of the analytical methods in use today, he originated to serve his needs in this work. The importance of his analytical work may be estimated by trying to imagine how a chemist could carry on today without atomic weights, for the basis of all his reckonings.

Along with and following Berzelius, other chemists well known to all students—Gay Lussac, Dumas, Roscoe, Rose, Bunsen, Berthelot, Beilstein, Fresenius, Liebig, Nernst, Ostwald and others—all used their talents in advancing chemistry by developing analytical methods. Procedures worked out by these men are standards today.

Since the time of these pioneers, development has been rapid. Today there is no compound which can defy analysis. The analytical methods and instruments have become remarkably accurate and delicate, serving to determine reliably, even unbelievably small traces. Today we carry on analyses by gravimetric, volumetric, colorimetric, electrolytic, electrometric, optical, thermal, X-ray and other means. Analysis has become a tool of precision and of universal use and service — used in every imaginable way in the services of all branches of science and industry.

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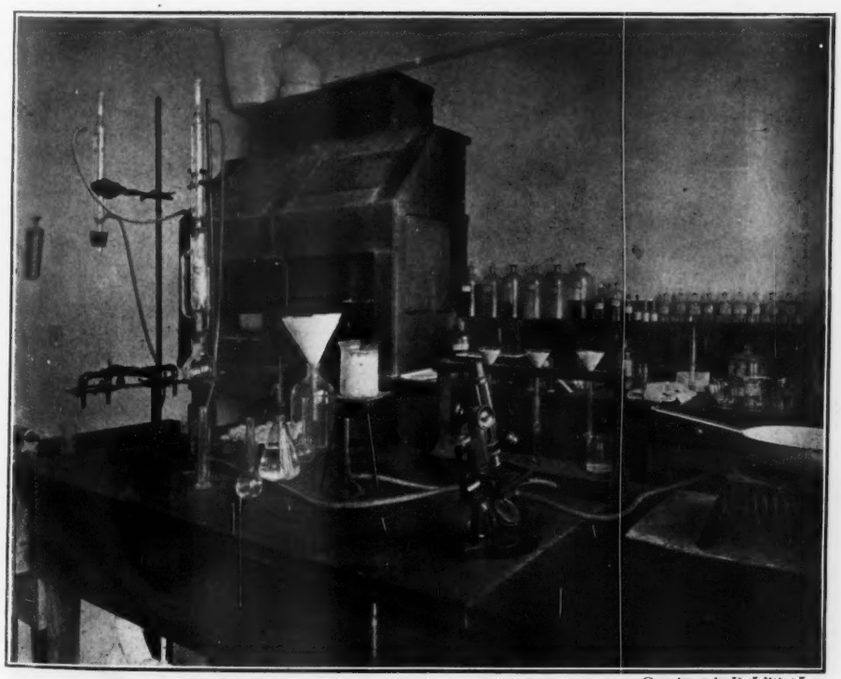
A TYPICAL MODERN ANALYTICAL LABORATORY

Industrial concerns have found them essential today for their control work.



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PORTION OF TEXTILE LABORATORY

This laboratory was set up by a young chemist to establish scientific control in a plant which wished to progress.

And yet students of chemistry often fail to realize the value of the training given them in analytical work. It is because they do not feel and appreciate this background, nor perceive the full utility of what they learn. Analytical chemistry is the one branch of chemistry indispensable to any chemist, no matter what his field,—inorganic, organic, physical, colloidal, etc. The prosecution of work in any chemical field requires analytical results to mark its progress.

Students will even sometimes complain that the instruction and exercise they get in quantitative analysis is tedious, or uninteresting. Such a statement means that they cannot see either backward or forward, farther than the ends of their own student noses,—or, that they have within them none of the makings of a chemist of any sort.

The student interested in chemistry really finds much to interest him in quantitative work. Beside teaching general chemistry, imparting manipulative skill, and giving ability to follow exact procedures and make accurate measurements,—it gives that indispensable power mentioned earlier, of being able to find out the truth concerning the composition of an object, when this desired data is unknown. The student can feel with Scheele, "the thrill of establishing his own chemical truths." These are things necessary to

(*Continued on page 224*)

TECH'S AUXILIARY FLEET

By ELLIOT SNOW
Captain, Construction Corps, U.S.N.

THE entrance to the School of Naval Architecture, M. I. T., a building erected from the bequest of Charles Herbert Pratt, in which the Marine Museum is located, is familiar to all students and other passers-by whose journeyings lead them to and fro on Massachusetts Avenue. Yet it is doubtful if any of the R.O.T.C. groups of students, while engaged in plotting this building, as part of their instruction in military reconnaissance, have raised their eyes sufficiently to gaze upon the Roman war galley over the doorway. The archeological experts in the senior class of the Department of Naval Achitecture and Marine Engineering steadfastly refuse to vouch for the accuracy of detail of the ancient craft. They claim assiduously, and probably rightly too, that the instructing staff of that Department has said nothing about either "zenzile" or "scaloccio" arrangements of medieval oarsmen.

The galley appears to have been designed for "zenzile" rowing—a very early arrangement of oars, in which several were thrust through a single port. The "scaloccio" arrangement, which was used as early as 1400 A.D., calls for several oarsmen on a single oar. The reference to this early period of time is not for the purpose of conveying the idea to green freshmen that the present "Tech" buildings are of an equally early date. The new buildings were first occupied in 1916.

The marine prints and ship models now on exhibition include some of "Tech's Auxiliary Paper Ships" and many of "Tech's Paper Navy." The former is more briefly referred to as the "Taylor Collection," and the latter, as the "Clark Collection." One who desires to be strictly accurate, when referring to the first named collection, should designate it as "The Marine Collection, Gift of Charles H. Taylor."

The preface to the first volume of "Sailing Ships of Old New England" refers to this benefactor of Tech as follows:

"Mr. Charles H. Taylor has probably the largest collection of ship pictures in private hands in New England. It contains numerous examples of the work of the artists about the Mediterranean. He generously made this collection accessible to us."

His public spiritedness led him to donate about seventy-five prints of his collection to the Marine Museum of Technology. To maintain uniformity of mounting and classification, the prints of this collection are mounted on cards of the sizes used for the "Clark Collection."

The Clark Collection method of classifying the index cards is also used. Small colored metal targets are clipped, in definitely assigned positions, to the upper edge of each index card whereby it is possible to locate the century in which the vessel existed, its type and method of propulsion, that is, whether by steam power, sail, or oars. Also, for naval vessels, one can quickly determine whether the print shows a fleet engagement or a single combat.

The "Taylor Collection" with the much larger one known as the "Clark Collection," also owned by Technology, when combined with future gifts, that it is to be hoped will follow, will some day make "The Technology Collection" the nearest complete of its kind owned by any educational institution in the United States and possibly anywhere in the world.

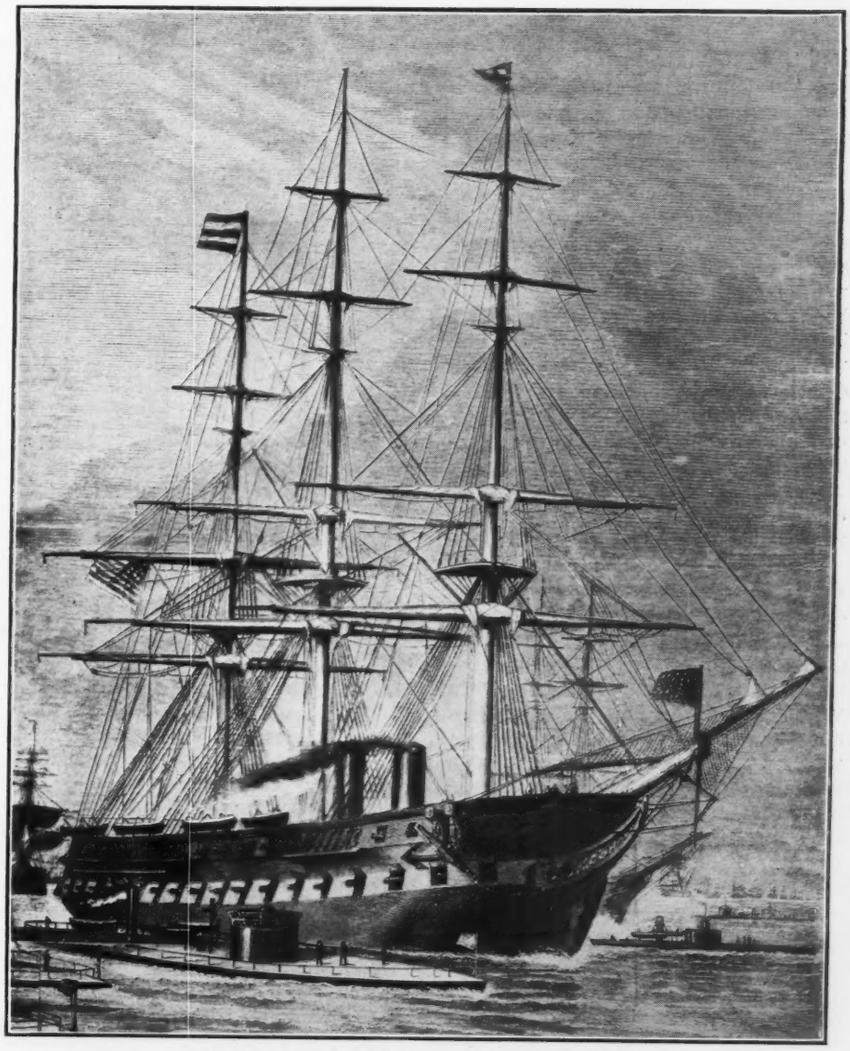
The largest private collection in the world comprises some seven thousand five hundred items, and is owned by Mr. A. G. H. Macpherson of England. The next largest private collection, in so far as is known to the writer, is that of Commander Sir Charles Leopold Cust, Bart., K.C.V.O., C.B., C.M.G., C.I.E., R.N. This is in the custody of Harry Parker, a celebrated print dealer of London, who, himself, has a large collection for commercial purposes.

The famous Chinese junk "KEYING," which appears on the cover page of this issue, is not one of the "Taylor Collection," but is one of the "Clark Collection." This is the first

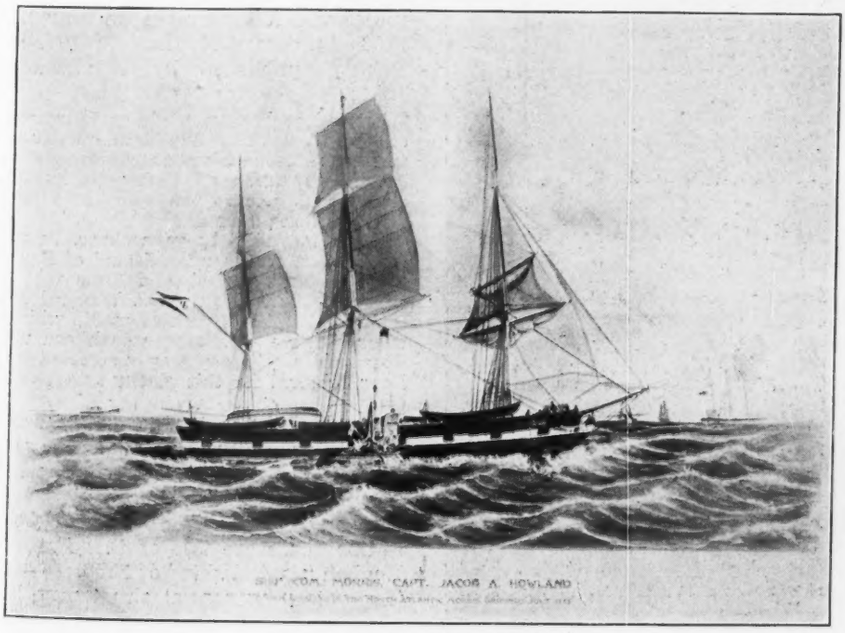
CHARLES H. TAYLOR
Donor of the marine collection known as "Tech's Auxiliary Paper Ships."

"great ship" of China that ever rounded the Cape of Good Hope or appeared in British waters. After her arrival there, her commander, Captain Kellet, met with many vicissitudes; one of them being his arrest for failure to pay his debts. Improvident undergraduates will have a fellow feeling for the unfortunate skipper of this junk. The word "junk" by the way, is an English corruption of the Chinese word "jong" or "ajong," which means "big ship." Recently the "Mariner's Mirror" published an interesting illustrated article about this "big ship." The cut shown on the cover, published May 20, 1848, by Rock Brothers and Payne of London, is different from any shown in the "Mariner's Mirror."

The Marine Research Society of Salem, Mass., the American Society that interests itself in early maritime matters, of principal interest to the citizens of the United States, has issued two profusely illustrated volumes of "Sailing Ships of New England." The first in 1922, and the second in 1924. Many of the illustrations of vessels therein reproduced are from prints and paintings owned by the donor of the "Taylor Collection"; others were obtained from the Peabody Museum of Salem, Mass. To digress a moment from the theme of this article, the writer desires here to say that any student who has half a day's leisure can devote it profitably and pleasurably to visiting that museum. While there, he should give particular attention to the Japanese and Chinese sections. These are, in some respects, the best of their kind in the occidental world.



FLAGSHIP FRANKLIN—CIVIL WAR PERIOD



SHIP COMMANDER MORRIS

This ship is shown engaged in sperm whaling in the North Atlantic.

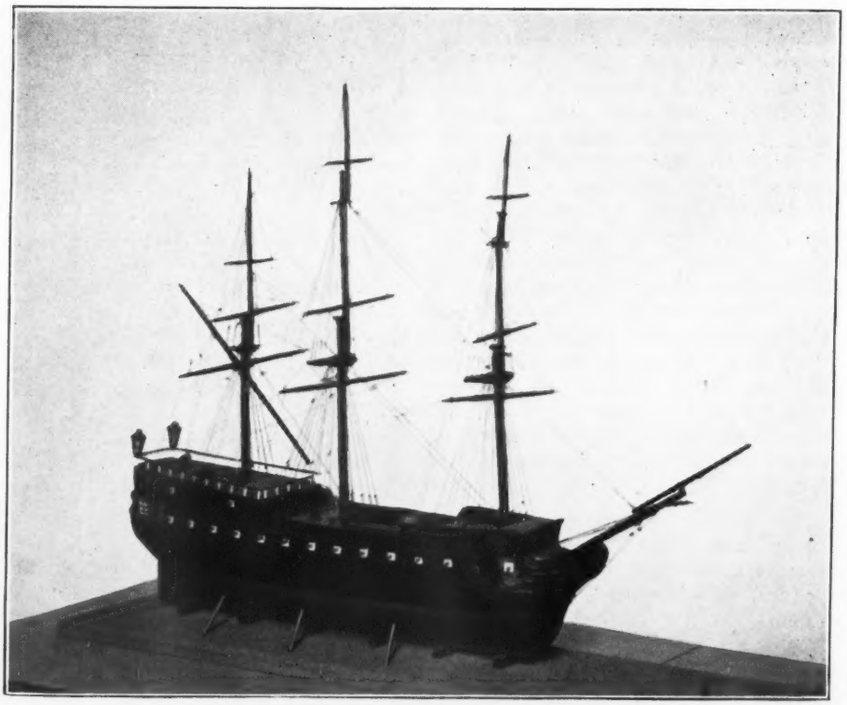
The Taylor Collection includes several proof copies of U. S. naval vessels, printed in colors from paintings by the artist, W. A. K. Martin. The cut, which shows the U. S. ship of the line *Franklin*, is an illustration. This vessel was one of six line-of-battle ships laid down and built in 1815. A line-of-battle ship, as its name indicates, was intended to take the brunt of the shock of battle. These vessels had full batteries on at least two decks, and carried square rigged sails on three masts. The *Franklin* displaced 2,257 tons, was rated as a 74-gun ship, but actually carried 64 long guns and 24 carronades, and her original cost was $438,000. She, like her successor, the U. S. steam frigate *Franklin*, bore, as a figurehead, a bust of Franklin.

The flagship *Franklin* carried the flag of Admiral David G. Farragut, U.S.N., on his European cruise in 1867-8. The cut illustrating this his-

toric vessel was taken from an old illustrated periodical, believed to be *Ballou's Pictorial Drawing Room Companion*, published in the late 60's.

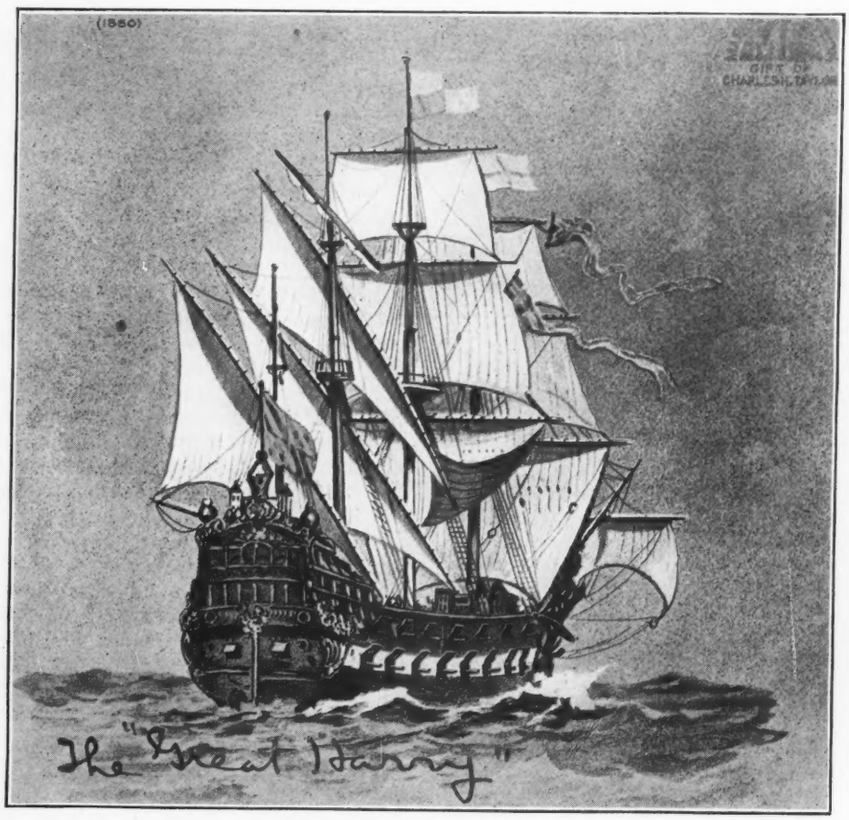
The whaling industry of New England is now virtually an abandoned industry, but its history will be ever present, and incidents connected with it are still full of interest. It has been described many times in song, poetry and prose, and often depicted on prints. One of the latest authentic books on whaling that appeared the latter part of October of this year (1924) was written by the late Charles Boardman Hawes. The print shown in this article "T-190" is one of the Taylor Collection, issued in 1859. It shows a sperm whaler taking its boats aboard. Unfortunately, much of the beauty of the print is lost in reproduction because of lack of color.

An inspiriting color print of the *Bon Homme Richard*, the flagship of John Paul Jones, bowling along under full sail, is one of the collection, but is not here illustrated. Instead, a view of the Boucher model of this vessel is shown. This small craft is one of a dozen or more models of naval vessels that are to be found in the room adjacent to the one in which some of the Taylor prints are now to be seen. It was in February, 1779, that the King of France gave Benjamin Franklin permission to buy and equip the old French Indiaman, *Duras*, which was afterward renamed in Franklin's honor, the *Bon Homme Richard*.



THE "BON HOMME RICHARD"

This is not the original flagship but is the Boucher model.



AN ENGLISH CAPITAL SHIP OF 1550

A line engraving published by the *London Magazine* for June, 1748, shows five English ships of the line and a frigate under double reefed topsails engaged off the island of Tortuga. No record of this print can be found in the writer's copy of "Naval Battles" of the Cust Collection, nor is it referred to in "Old Naval Prints, Their Artists and Engravers," by Commander Robinson of the Royal Navy. An engagement in the West Indies which took place on May 28, 1708, is described thus in "Naval Prints," published by H. Parker, 1921:

"Commodore Wager, while in Command of the West India Squadron consisting of four ships, received intelligence of a Spanish squadron off Cartagena having on board specie to the value of forty-eight million pieces of eight."

"Wager immediately gave chase. In attempting to weather the Island of Baru, the Spaniards tacked, and came within range of the British ships. Wager himself attacked the Spanish flagship which, after a fierce encounter was blown up. Commodore Wager was promoted to Rear Admiral for this plucky attack and capture."

This reference to the engagement off Portipea naturally leads one to say that no collection is really complete unless it has one or more views of the *Great Harry*. In the Taylor Collection there are two of this famous English "capital ship" of 1550. To call this vessel "a capital ship" may be considered by very critical readers to be an anachronism. This term is, of

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PATENT ENGINEERING—A COMING PROFESSION

By ROBERT E. NAUMBERG, '16

In Charge of the Patent and Research Department, Saco-Lowell Shops, Lowell, Mass.

OUR engineering schools turn out engineers who know little or nothing of patent law; our law schools turn out lawyers who know little or nothing about engineering.

Where shall our patent engineers come from?

I would define a patent engineer as a person who can design a new machine in accordance with a knowledge of patent law and of existing patents, just as intelligently as a mechanical or civil engineer designs a piece of mechanism or a structure in accordance with the laws of nature. A patent engineer is no more discouraged by a legal obstacle than a mechanical engineer is by a mechanical obstacle. To each—it is his problem. He revels in it—and eventually he solves it.

This is an age of increasing complexity. New sciences are being discovered, laws of nature hitherto unknown are being added to our sphere of knowledge. The man who is first to grasp the new complexities is that much further ahead of his fellow men.

Just as a man with a knowledge of mechanical drawing can outstrip the man who "built the bridge and drew the pictures afterwards," so can the man who understands patent law leave his untrained rival far behind, struggling in the mire of supposedly insuperable difficulties.

It is commonly believed that a manufacturing concern should employ engineers and designers regularly, but should call in the services of a patent attorney only when occasion requires. This is far from true in any of the mechanical industries where the patents of the concern itself, and of its competitors, play an important part.

No person detached from a concern can understand all the sides of a situation. He will understand only the things which are pointed out to him, plus the points which his particular training will suggest. A patent attorney called in for advice in regard to a new machine designed so as not to infringe existing patents, can give only negative advice. He will tell you what you must not do. He is neither a mechanic nor an inventor, and cannot devise the new means.

One well known firm of consulting engineers states in its prospectus that it will not accept any work in connection with finding a means to avoid existing patents. This firm no doubt considers this to be a very high ideal, and no doubt it was prompted by very lofty motives. But if that policy were pursued by manufacturing concerns throughout the country, progress would be very greatly reduced. Many very important inventions and discoveries have been made by those forced to find "another way."

To cite one specific example—in the worsted industry there is a machine called a "gill-box" which combs or draws out the fibers. A series of combs or "fallers" are propelled forward by a pair of screws called "gill-screws." The "fallers" are returned or propelled backward on another level by means of a second pair of "gill-screws." The transfer of each comb or "faller" from one pair of screws to the other is performed by means of cams. Formerly these cams were fitted to the screws by hand, and when a cam broke (which occurred quite frequently), to replace it was a very slow and laborious operation.

A manufacturer of gill-screws conceived the idea of mounting the cams on a disc and slipping this disc over the end of the screw, and holding it in place by means of a key and set-screw. He obtained a patent on a disc-cam which could be slipped on and off over the end of the gill-screw, and he apparently had a monopoly of the field.

A firm of textile machinery manufacturers was desirous of making gill-screws for its gill boxes, but was apparently blocked by this patent. A study of the patent situation, combined with a little ingenuity in designing, resulted in the construction shown in the accompanying photograph.

The cam was still a disc, but was made in two parts, being split in the middle. The two halves were held together by a collar and lock-nut. This disc could be put on or taken off without slipping it over the end of the screw.

The fact that the first patent was completely avoided, and that a patent on the split-cam was obtained without even a reference by the Patent Office to the older patent, is only half the story. As far as functioning in the gill-box was concerned, both constructions were satisfactory.

But now for the other half of the story—a half which was entirely overlooked in the original attempt to avoid an existing patent: To put it briefly, a gill-box is rather an inaccessible machine, and in addition, it must be timed perfectly in order to operate. Whenever it is necessary to take out a gill-screw, the machine must be torn down and the timing disturbed. On the average, two to fours hours of a mechanic's time is consumed, not to mention the loss of production of the machine, and the possibility of a careless mechanic timing the gill-box incorrectly with subsequent damage.

The new construction made it possible to change cams without removing the gill-screws. It was only necessary to use a wrench to unscrew the lock-not, take off the collar, and the two

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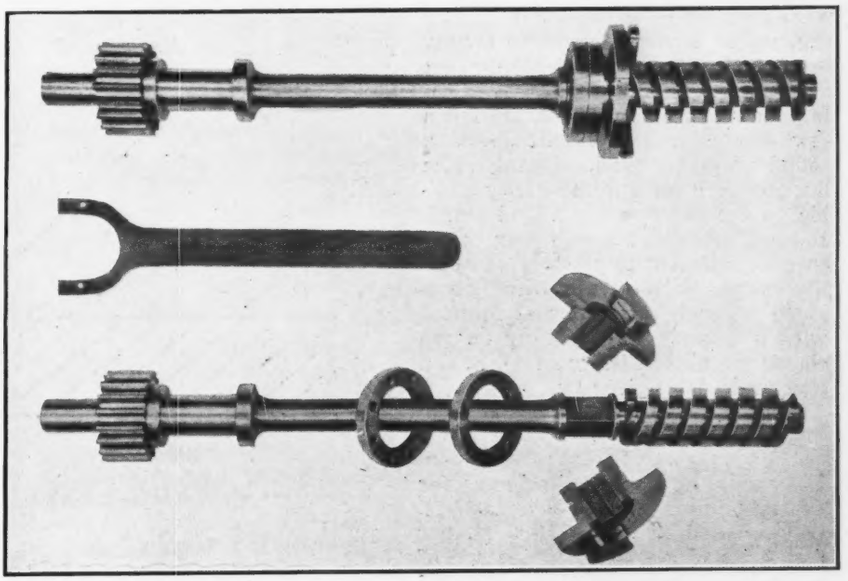

THE GILL-SCREW WITH THE SPLIT-DISC CAM

By splitting the disc it was possible to overcome opposing patents.

ARCHITECTURAL ACOUSTICS

By WILLIAM R. BARSS

Assistant Professor of Physics, Massachusetts Institute of Technology

THE application of engineering acoustics to the design of public buildings is one of the more modern sciences. Previous to the present century a building was constructed according to the architect's design with the hope that it would prove to be acoustically satisfactory. Sometimes it was, more often it was not. The uncertainty of such procedure gave rise to investigations whose object was to determine the causes of prevailing defects, and to supply some remedies for them. One cannot write an article on this subject without paying tribute to the master pioneer, the late W. C. Sabine, whose painstaking researches on Architectural Acoustics have placed the whole matter on a scientific basis and have provided us with a vast amount of material relative to acoustic defects and their possible alleviation. While our present knowledge of the acoustics of buildings is incomplete in many respects, yet enough is known to make it a scientific problem, the principles of which should be incorporated in the design of every public building. The object of this article is to place before the reader some of our present knowledge of the subject.

Sound consists of a series of condensations and rarefactions which start at the source, and that progress, as longitudinal waves rapidly outward in the surrounding medium. Any vibrating body may be a source; the vocal cords of the human voice, the pulsations set up in the air within an organ pipe, a vibrating violin string, the walls and floors of a building that are set in motion by machinery within, or street traffic without, are but a few examples. The amplitude of a sound wave is small, varying from 5×10^{-8} inch for a sound barely audible, to 4×10^{-3} inch for a loud sound. A small motion of a wall may therefore be sufficient to produce an audible sound. Sound waves are propagated through any material medium with a velocity V depending on the elastic modulus of the medium, E, and its density D as given by

$$V = \sqrt{\frac{E}{D}}$$

The values of V are quite large; for example, in air at O°C, V is 1,088 ft. per sec. and in steel 16,360 ft. per sec. A sound generated in one end of a steel structure 200 ft. high would require only 0.0122 sec. to reach the other end.

When sound waves in one medium meet a second medium differing from the first in elasticity, density or both, their regular progression is stopped. Three things are liable to happen. Some of the energy of the incident wave is reflected back into the incident medium, this reflection obeying the well known laws which govern the reflection of light; part of the energy of the incident wave is transmitted through the second medium, and the part which is neither reflected nor transmitted must be absorbed within the disturbing medium itself. This is illustrated in Fig. 1. The relative amounts reflected and transmitted depend on the change in elasticity and density between the two media. To illustrate, a porous material like hair felt will have a small reflection but a large absorption. On the other hand a solid plaster wall may reflect as much as 99 per cent of the energy incident upon it, leaving little to be absorbed. From the conservation of energy principle, it must follow that

$$I = R + T + A \quad \ldots\ldots\ldots (2)$$

no matter what may be the relative values of R, T and A.

The absorption and transmission of sound vary with the thickness of the absorbing medium according to the relation

$$I = I_0 a^{-x} \quad \ldots\ldots\ldots (3)$$

where I_0 and I are the intensities of the sound which enters and is transmitted respectively, (x) is the thickness of the material and (a) is a constant depending on the material itself.

When sound energy is absorbed it is transformed into heat by friction between the oscillating air particles and the sides of the pores through which the sound is passing. This absorption is a necessary factor in sound insulation. Energy cannot be absorbed by scattering or reflection, it must be transformed by friction into heat energy.

Transmission may occur in two ways. First, sound waves may pass through the air spaces in a porous material. The transmitted wave is usually reduced in intensity as some of the energy has been transformed into heat during the passage. Second, sound may be transmitted by setting a wall or part of it into vibration. This depends on the rigidity and massiveness of the wall. Consider the case of a wall built of plaster on wood lath and studding. The plaster areas between the studs may act as a diaphragm and transmit sound. Transmission is not a simple matter. It depends on the nature of the structure and can be calculated only for simple cases in which the structural material is homogeneous.

A closed room may give rise to two acoustical defects, namely distortion and reverberation. There will be certain points in any room where one or more components of a composite tone will be reinforced by interference while other components may be weakened by interference. This means a change in the relative loudness of the various components and possibly a change in quality of the composite

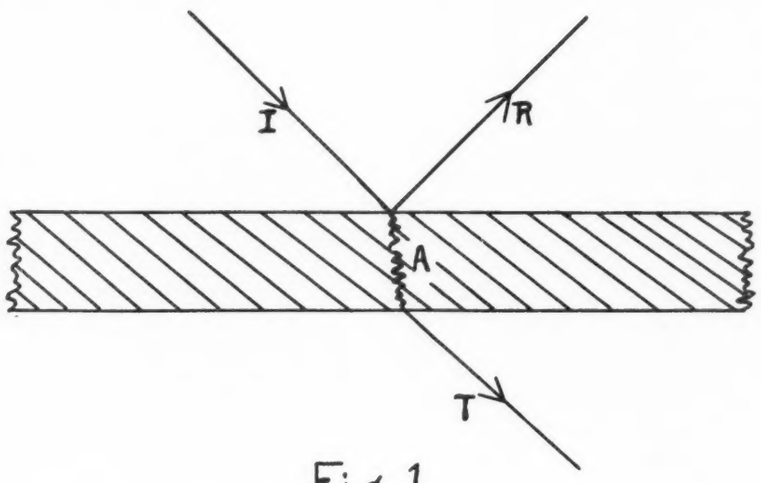

Fig 1.

tone. In addition the air in a room has a natural period of vibration and any tone in unison with this tone will be reinforced by resonance. This effect is most noticeable in small rooms or rooms having alcoves. Distortion in general is not a serious matter.

Sound reaches an auditor in a room by waves coming directly from the source and also by waves which are reflected from surfaces within the room. The various paths from source to auditor usually differ in length so that the various reflections usually reach him in different time intervals. If the room is large these various reflections may be separately heard as "echoes." If the room is small the various reflections blend into a continuous roar, which is called a "reverberation." Reverberation time may be defined as the time taken for a sound to reach zero audibility after the source has stopped sounding. Sabine defines it as the time for a sound to damp to 10^{-6} of its original intensity after the source has stopped. This condition is, practically, zero audibility. Cases are on record where the reverberation time has been as high as 10 seconds. Zero reverberation time is not desirable as a room under such conditions is acoustically dead. In general, from one to two seconds is not excessive. Sabine,[1] after years of experimental research, arrived at the following empirical relation:

$$T = 0.164 \frac{V}{a} \quad \ldots\ldots\ldots (4)$$

(T) being the reverberation time, (V) the volume of the room and (a) the open window equivalent of all materials within the room. An open window may be regarded as a non-reflector, that is, a perfect absorber, since all the sound incident upon it is transmitted through it. If (x) square feet of any material absorb as much sound energy as one square foot of air, one square foot of that substance will absorb $\frac{1}{x}$ as much as one square foot of air. This is called the absorption coefficient of that particular material. This coefficient multiplied by the area of the material in the room will give the open window equivalent for that material. The quantity (a) in equation (4) is the sum of the open window equivalents for all materials in the room.

This same problem has been solved theoretically by Franklin[2] with the following result:

$$T = 0.161 \frac{V}{a}$$

[1] Collected Papers on Acoustics, by W. C. Sabine.

[2] Light and Sound, by Franklin and MacNutt.

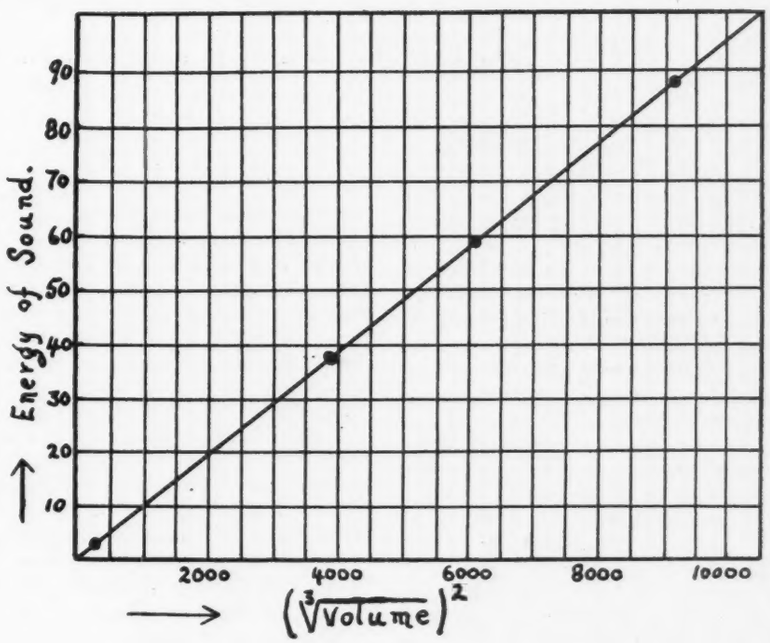

Fig 2.

Absorption coefficients have been determined by Sabine and others for materials which are ordinarily found in an auditorium. Some of the most common are given in the following table:

Sound Absorption Coefficients	
Brick wall	per square meter 0.032
Carpets	per square meter 0.15–0.25
Concrete	per square meter 0.015
Chenille Curtains	per square meter 0.23
Glass	per square meter 0.027
Linoleum	per square meter 0.030
Oil paintings	per square meter 0.28
Plaster on wood lath	per square meter 0.034
Varnished wood	per square meter 0.030
Hair felt	per square meter 0.78
Audience	per person 0.47
Church pews	per seat 0.20
Upholstered seats	per seat 0.10–0.25

It will be noticed that materials having the highest absorption coefficients are not always available or desirable. Open windows and an audience have large coefficients. Open windows are not desirable in cold weather and an audience is not a constant quantity. Hair felt which is used extensively must be carefully prepared to make it sanitary and fireproof. It is heavy in large quantities and hard to handle as a building material. This and other materials such as flax board, Cabot quilt, etc., are usually covered with thin, porous cloth for decorative effects. The cloth soon becomes soiled. Painting tends to reduce porosity and consequently absorption. An artificial stone "Akoustolith" has been developed which is sanitary and fireproof. It has an absorption coefficient of 0.36 per square foot. It is not as efficient as hair felt and is more expensive. There is a great need for development along the line of producing some material which has desirable properties without the undesirable ones.

The remedy for excessive reverberation is to place in the room sufficient absorbing material to reduce the time to a satisfactory value. The area of the material may be calculated from equation (4), T and V having been measured. This treatment may be applied to buildings already constructed, or it may be incorporated in the design of a proposed structure. The later is obviously preferable, as finished rooms do not always lend themselves gracefully to proposed treatment of this nature. If the acoustics are considered in the plan of a building, the materials and designs recommended may be installed during the process of building, which in general will reduce the expense. On the other hand the straightening of curved walls, removal of alcoves or even the introduction of absorbing material may not be desirable, so that the corrections for faulty acoustics in a constructed building are not always successful.

There are at least three factors which should enter into the acoustic design of a room. First, the volume of the room should be in proportion to the intensity of the sounds to be generated in it. For great intensity, such as a band concert, the volume should be large; for speaking, the volume should be considerably smaller for proper distribution; when used for

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THE SEARCH FOR COVERED OREBODIES

By WALDEMAR LINDGREN

William Barton Rogers, Professor of Economic Geology, Massachusetts Institute of Technology

ALMOST all of the celebrated ore deposits of the world have been discovered by means of their outcrops on the surface. Some, indeed, stand out like mountains visible from far and inviting the miner by treasures open to the day. Such are the iron mountains of Gellivare and Kiruna in northern Sweden with their enormous masses of magnetite; the Magnitnaya Gora or the Magnetic Mountain of the Urals; or the Iron Mountain of Wyoming with its, as yet, untouched great body of titaniferous magnetite. Others, with less conspicuous outcrops, were easily found by the prospector as the unequaled silver veins of the Cerro de Potosi in Bolivia, or the similar deposit of the Comstock Lode in Nevada. Still others less conspicuous have needed the careful tracing of "float" to its source. Accidents have helped in other cases. Sullivan's mule, for example, in a fit of temper kicked the thin covering off the outcrop of the great Bunker Hill and Sullivan lead mine. At least that is the tradition current in the West.

Since the dawn of mining it has become evident to the searchers for mineral riches that many deposits, covered by overburden, still remain to be discovered. The most evident method is to sink and explore the rocks below this overburden, but, naturally, this may be an uncertain and costly proceeding. Other bodies have been found in the vicinity of known deposits by cross cutting or following obscure "leads," for where one mass of ore exists others are likely to be found in the vicinity.

Since ancient times the divining rod—a forked willow twig—has been used in the hands of pretended wizards to find ore, water, and oil. The story of the divining rod is most interesting. (See "The Divining Rod," by A. J. Ellis, Water Supply Paper 416, U. S. Geol. Survey). It is doubtful whether so much investigation and discussion have been bestowed on any other subject with such absolute lack of positive results, and it ought to be obvious to every one that this method is entirely discredited.

There are other methods, however, resting on more scientific base. Some of them are old, others very recent. In substance they are based on the variations in the magnetic field, the electric field, or the gravity caused by the position of an orebody underneath the surface, a body differing in various ways from the ordinary rocks.

Magnetic Methods

I shall first take up the magnetic methods. For two centuries the "dip needle" has been used in Sweden for the discovery of covered magnetite ores. It is a balanced needle swinging in a cylindrical box and free to move in a horizontal and a vertical direction. Above the ore the vertical attraction is strongest. Naturally this is a crude instrument, but it has rendered notable services. Its use is not confined to magnetite. Other iron ores like those of the Lake Superior country and many limonites and iron carbonate contain a small amount of magnetite which will notably affect the needle. Also, of course, there is pyrrhotite which is common in many large pyritic orebodies, and most varieties of pyrrhotite affect the needle somewhat. Other minerals like pyrite, chalcopyrite, and galena are inert.

This method has been perfected in the Lake Superior mining region where the hematites as a rule contain enough magnetite to affect the needle, and it has been described by Professor H. L. Smyth in a paper in Volume 36, of the monographs of the U. S. Geological Survey.

Essentially the method consists in determining the horizontal and vertical components of the magnetic field at a network of points in the area to be examined. The horizontal component is determined by the dial compass which permits the determination of the meridian on any clear day. The vertical element is obtained by a balanced dip needle swinging in the meridian along a graduated circle.

Thus curves of equal intensity are constructed and, from the course of these, conclusions may be drawn as to the depth of covering, the strike of the strata, and the approximate size of the deposit. Incidentally it may be mentioned that late work by Dr. Hotchkiss has shown that the dip needle can be used for the location of covered faults or covered contacts between rocks of varying but slight content of magnetite. It promises, therefore, to be a useful instrument in geological fieldwork.

A more exact method has been worked out in Sweden since 1879 and is largely used for the study of the magnetite deposits of that country. In Canada likewise many examinations have been made according to this method and are published in the papers of the Department of Mines. The instrument used is called the "magnetometer," and there are two types in use: One is the original Tiberg-Thalen instrument; the other the Thomson-Thalen magnetometer. The former consists essentially of a compass box (which may be reversed and also used for vertical measurements) and a sliding compensating bar magnet attached to a horizontal arm. The instrument is not used to determine the meridian but is read first with the compensator in a certain determined position and second with this compensator removed. This gives a variable "angle of deviation" and curves are constructed showing the equal angles of deviation at a great number of points. These are called isodynamic curves and permit rather exact determination of the position of the magnetic pole of the ore deposit and its approximate size and position in the earth. Similar isodynamic lines are constructed for the vertical intensity of the magnetometer methods by Professor H. L. Smyth are found in volumes 1 and 2 of Economic Geology, and a more detailed account by Eugene Haanel is published by the Department of the Interior of Canada as a small volume, Ottawa, 1904. Naturally, this method can be used for any orebody which is at all megnetic.

Electric Methods

It has long been known that electric currents are generated in ore deposits by the contact of electrolytic solutions (salts contained in the groundwater) with metallic minerals. The first experiments along this line were made by Professor Barus, now at Brown University at Providence. He conducted examinations in 1884 at the Comstock Lode and at Eureka, Nevada, but came to the conclusion that the currents generated were too feeble for any such electrical method to have practical results. However, during the last few years more successful methods have been devised and are now attracting much interest. Briefly these are based on the fact that minerals with metallic lustre are much better conductors than ordinary rock minerals, and that by measuring the disturbance of the electric field at a network of points conclusions may be drawn as to the presence below of a mass of good conducting material.

Evidently electrical prospecting is not easily applicable to small veins, or veins poor in metallic minerals. Also

it should be observed that some ore minerals, like siderite or sphalerite, are poor conductors.

There are two methods of electrical prospecting: First, that depending on the transmission through the earth of independently generated electric current. This appears to be the more successful way and may be called the Lundberg method. An explanation of it was published in 1922 by the Geological Survey of Sweden in a pamphlet, entitled "Practical Experience in Electric Prospecting." By application of this proceeding two important sulphide deposits have been discovered in Northern Sweden where they were deeply covered by glacial detritus.

A single phase alternating current of say 100 volts is connected by insulated cable through a double-pole, double-throw knife switch to two spaces, perhaps 1,000 or 2,000 feet apart. Each space consists of connected brass pegs, driven a couple of feet in the ground. The presence of an orebody below will disturb the normal electric field of the current with its gradually dropping potential. For study of the distribution of the current under the disturbing conditions searchers are used consisting of two non-polarizing electrodes and a potentiometer. The latest improvement consists in the use of a telephone in locating the equipotential curves. After these curves have been traced on the map certain interpretations may be derived from them.

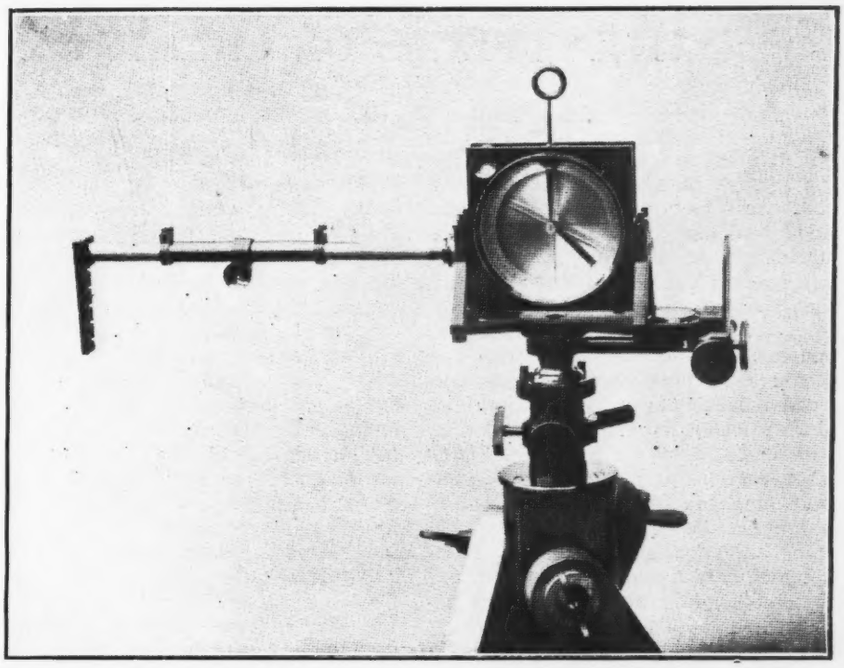
The fall of potential (E) is everywhere dependent upon the density of the current (I) and the specific resistance of the ground (R), in accordance with Ohm's law:

$$E=I.R.$$

In neutral ground the specific resistance is great, the density low, and the fall of potential fairly large. In the ore ground the current density is great, but the specific resistance so small that the fall of potential becomes insignificant. The curves will, therefore, give a direct indication of the presence of a good conductor below the surface.

The second electrical method may be called the Schlumberger method, after Professor Schlumberger of Paris. It has been used to some extent in this country, and especially in Canada where some deposits at Flin Flon Lake, Manitoba, have been examined. (See paper by S. F. Kelly in the Am. Inst. Min. & Met. Engs., Canadian Meeting, 1923.) Its usefulness depends on the detection and measurement of electrical currents generated within the mass of certain types of ore deposits—that is currents of "spontaneous polarization," which seem to be the result of oxidation within the bodies. The direction of the flow of electricity is from the mass of sulphides in the oxidizing zone, down through the vein, out into the surrounding country, up to the surface, and back into the ore. About the "negative center" or the point of greatest concentration of the current at the surface, equipotential curves are now traced by means of the non-polarizing electrode and the potentiometer as in the first method.

The equipotential curves mark, naturally, the outlines of the electrical field generated by the ore body, and will permit certain conclusions to be drawn as to the presence of a good conductor below.



THALEN-TIBERG MAGNETOMETER (SET UP AS INCLINATOR)

Variations in the Gravity

Last year this department received a rather remarkable request for an assistant geologist. He was required to be an expert mathematician, very strong physically and should thrive in a southern Texas summer sun. This seemed a pretty hard combination, and it ultimately developed that the man was expected to transport, set up, and observe an Eotvos torsion gravity balance for the exploration of an oil company in the sunny South. As will be seen from the following another requirement for this position is patience unlimited.

The researches of Professor Eotvos in Buda-Pest have long been familiar to students of gravity, but only recently his name has become widely known on account of this marvelously delicate instrument, which records the changes in the direction and force of gravity induced by any abnormal mass in the earth below the point of observation. It would indicate, for instance, a mass of magnetite or other heavy geological body; or it would point to the presence of a lighter body of rock salt; or it would indicate the occurrence of an anticline of folded rocks below the surface. It is, indeed, for this last purpose that it is now coming into use among oil companies in Texas and California. It does not show the presence of oil but gives indications of the existence of the saddle-like compressed folds of sedimentary rocks with which the oil is often connected. At the present time it is still in the experimental stages but bids fair to develop into a very useful instrument.

Really it is a Coulomb torsion balance of great refinement. A light aluminum bar is suspended from a thin platinum wire and on the two extremities there are platinum weights. With the aid of the compass the instrument is set so that one of the weights turns to the north. Then the instrument is left alone until the balance has come to rest. This requires about one hour. The instrument is then successively turned in four other positions and at each step the position of the balance is read on the scale. From these data the *horizontal directing force* of the gravity can be calculated. The observations are made at night in a tent with padded walls and the instrument is enclosed in a metal case—all to exclude variations of tem-

(*Continued on page 230*)

THE EFFECTS OF CRANK CASE DILUTION

By D. P. BARNARD, 4th

Research Associate, Department of Chemical Engineering, Massachusetts Institute of Technology

THERE is probably no other instance in which an oil is called upon to perform such a wide variety of exacting duties as in the lubrication of the internal combustion engine. The oil must at the same time lubricate properly comparatively cool bearings carrying heavy loads, and hot cylinder walls, in which the piston ring pressures are comparatively small. This is particularly true of automotive and airplane engines, in which the oil is invariably recirculated, and the use of different lubricants for bearings and cylinders is impracticable. A single lubricant, to work under such conditions, must necessarily be a compromise which will meet sufficiently well the extreme demands imposed upon it. Ordinarily, the most suitable cylinder lubricant would be unsatisfactory for bearing lubrication, and the converse would be equally true. For this reason, it is necessary to manufacture internal combustion engine oils to rigid specifications designed to insure against their changing or deteriorating in service. Only one lubricating property (viscosity) of the oil is defined in these specifications—the other requirements serving to guard against viscosity changes, and such secondary effects as carbonization in the cylinder (Carbon Residue) and crankcase explosions and evaporation (Flash and Fire Tests).

Therefore, the specifications for testing indicate that the oil for any particular type of engine must have a suitable viscosity if it is to successfully meet the extreme conditions imposed upon it. Nevertheless, however careful the refiner may be in adhering to these specifications, there is one kind of deterioration which he cannot guard against. That is reduction in viscosity due to dilution by unburned portions of fuel, ordinarily called "crankcase dilution."

Experience has shown that crankcase dilution is most pronounced in engines which are operating "cold" or are started and stopped so frequently that large amounts of liquid fuel are drawn into the cylinders when choked for cranking. Airplane engines which, in addition to less frequent starting, run rather hot and burn more volatile fuels, are not seriously troubled by dilution. This is not true, however, of the automobile engine which, on account of the intermittent service to which it is subjected, is frequently started and operated at cylinder temperatures, which allow large amounts of "heavy ends" of the fuel to leak past the piston rings. This condition is aggravated during cold weather, with its accompanying prolonged periods of cranking and running choked. It has been estimated that the average winter-time start consumes at least one-half pint of gasoline, only a small part of which is actually volatilized and burned. A considerable amount of this unvaporized fuel dissolves in the oil film on the cylinder wall, trickles past the rings, and at once mixes with the oil in the crankcase. Only a surprisingly small amount of vaporized fuel is required to reduce the lubricant viscosity far below the normal figure. This is illustrated by the accompanying Fig. I, from which it is evident that the viscosity is more than cut in half by dilution with 10 per cent of kerosene. (Kerosene corresponds fairly closely to the heavy ends of commercial motor gasoline.) The two most important questions arising from this loss of viscosity by dilution are (1) its effect on the life of the engine, and (2) its effect on engine performance.

It is the primary purpose of this paper to present such information as exists in answer to the first of these questions. For this purpose it will be necessary to study the effects of dilution on the two principal types of bearing surfaces, the bearings (main and crankpin bearings) and the cylinders, with the pistons and piston rings working in them.

It is an established fact that bearings are lubricated most efficiently by a thick film of fiuid lubricant drawn into the clearance space by the powerful suction of the rapidly revolving journal. High-speed bearings are certain to fail within a very short time if such a film is not maintained. Therefore, the operating conditions of the bearing (bearing load, speed and oil viscosity) should be so adjusted as to give, at all times, the maximum possible factor of safety, in order to prevent rupture of the fluid film. It has been found that the value of coefficient of friction of a bearing is an accurate measure of the thickness of the lubricating film, a very high coefficient indicating metallic contact, accompanied by incipient seizing and abrasion, while a low coefficient indicates the presence of a relatively thick fluid film. Furthermore, it has been found that the coefficient of friction of any particular bearing is determined wholly by a quantity known as the "modulus of operating conditions," which is written

$$\frac{ZN}{P} = \frac{\text{viscosity (centipoises)} \times \text{speed (R. P. M.)}}{\text{normal bearing load (lb./sq. in. projected area)}}$$

At sufficiently high values of this modulus, the coefficient of friction is low, and lubrication is effected by a fluid film. As the value of the modulus is decreased, as by increasing loads or thinning of the oil, the film becomes thinner and may actually be completely broken. It is evident, therefore, that there is a minimum value of the modulus for any particular bearing, below which it is impossible to maintain a fluid lubricating film. It has been found, experimentally, that for bearings of the type used in internal combustion engines this minimum value is approximately 14 when expressed in the units indicated above. Obviously, a factor of safety above this value must be provided, the magnitude of which depends on the type of service to which the engine is to be subjected. A very good idea of the safety factors ordinarily used, may be gained from inspection of the following table, in which are given the approximate full load value of the modulus, $\frac{zn}{p}$, for the crankpin bearings. These values are all based on bearing temperatures of about 200°F.

OPERATING CONDITIONS FOR CRANKPIN BEARINGS

(Full Load)

Type	Engine	zn/p at Full Load	zn/p at Film Rupture
Airplane	Liberty 6 cyl.	38	14
	Maybach 5 cyl.	25	14
	Rausie E6	36	14
	Hispano 300	21	14
	Wright H2	21	14
	Curtiss K12	30	14
	Curtiss CD12	32	14
	Liberty 12	26	14
	Packard 1237	31	14
	Packard 2025	21	14
	Rolls Royce Eagle	29	14
	Napier Lion	31	14
	USA W-1	21	14
	USA W-2	17	14
	Lawrence L	34	14
	Lawrence J	18	14
Truck	USA Class B	60	14
	Mack AC	55	14
	White 3½-ton	55	14
Passenger Car	Buick 6 1920	44	14
	Buick 6 1923	38	14
	Buick 6 1924	35	14
	Chevrolet 1923	31	14
	Dodge 1923	31	14
	Essex 1923	31	14

	Oldsmobile 4 cyl. (1923)	30	14
Racing Car	Duesenberg 183 cu. 1923	80	14
	Duesenberg 122 cu. 1923	100*	14

As automobile engines operate for the most part of the time under comparatively light loads, the overall factor of safety is much greater than that indicated. It is so large that even a considerable reduction in viscosity will not ordinarily cause film rupture. On the other hand, during periods of rapid acceleration and hill-climbing "on high," the loads are heavy enough so that excessive dilution may prevent maintenance of the fluid film.

The factor of safety of the racing car engines is not so large as would appear on first sight. This is primarily due to the severe flexing of the journals at the high speeds involved (6,000 RPM). It is during these periods of maximum power output that the bearings suffer greatest wear, and if the viscosity of the lubricant is too low, they fail very rapidly. In most instances a 50 per cent reduction in viscosity will reduce the full load value of the modulus so dangerously near the point of film rupture as to completely remove the factor of safety.

Thinning of the oil by dilution, then, is a potential source of bearing failure, and even when not carried to the point of actually causing "burn-outs," is almost certain to materially reduce the useful life of the engine and to result in the necessity of more frequent overhauls. Fortunately, the tendency to dilute is much less marked in high duty engines than in those subjected to more intermittent operation. However, the danger of failure, due to dilution, is present in all types, and should be eliminated as far as is possible.

The effects of crankcase dilution are even more pronounced in the case of pistons and cylinder walls. Here it is impossible to maintain a fluid film, and lubrication must be effected by the inherent ability of the lubricant to stick to the rubbing surfaces in spite of the scraping action of the piston rings and evaporation at the temperature to which it is exposed. In all automotive engines the cylinders are lubricated by oil thrown from the rapidly revolving cranks, and the amount furnished is to a large extent independent of the viscosity of the oil. If the oil is badly diluted, so much of the comparatively volatile diluent may evaporate from the wall surfaces as to leave the parts inadequately protected. The outward signs of this condition are excessive cylinder noise and increased wear. In this connection it is worth noting that the results of some investigations at M. I. T.* indicated that the "danger line" occurred at about 15 per cent dilution. This corresponded to a viscosity decrease of approximately 70 per cent at 100°F. When this danger line was passed the rate of wear increased very rapidly. Cylinder and ring wear is due primarily to the loads resulting from the "spring pressure" of the rings themselves and is therefore substantially independent of the load on the engine. For this reason excessive wear due to dilution is almost always present, regardless of the kind of service to which the engine is subjected. Such wear usually increases markedly before the danger point for the bearings is reached.

*Not supercharged.

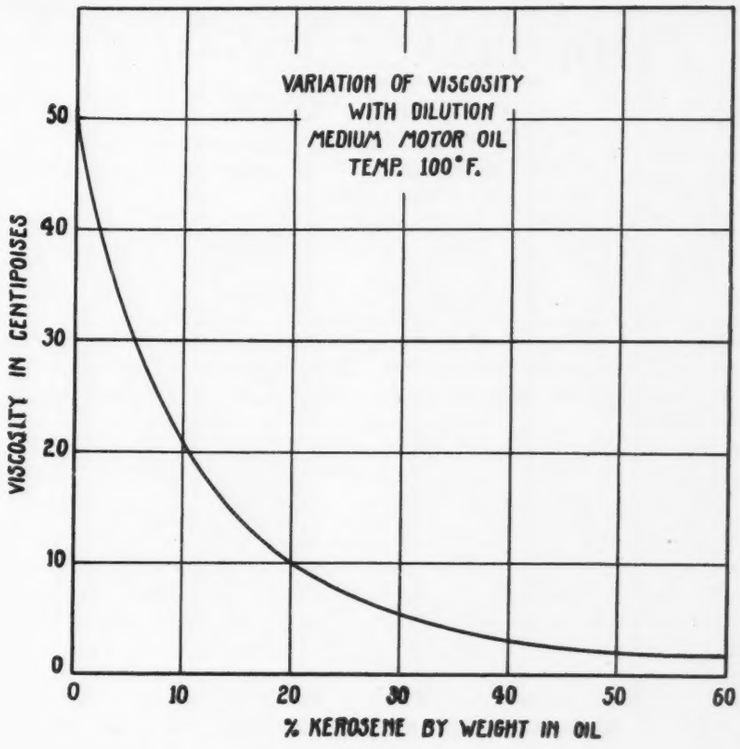


Figure 1

At the present time there is no evidence available to indicate any reduction in engine power by dilution. On the other hand excessive dilution is usually accompanied by a "harsh" or "hard" running engine, due to imperfect cushioning of the working parts. For instance, "sloppy" pistons tend to slap harder than they otherwise would, and increased vibration is noted which may be due to the crankshaft "shaking" in the main bearings. Even though dilution may not cause serious damage, it generally prevents the engine from operating as smoothly as it should.

* C. W. Stose, Chem. Eng. Thesis, 1923; E. R. Barnard, Mech. Eng. Thesis, 1924.

In general, crankcase dilution may be said to produce the following effects:

(1) Liability to bearing trouble, especially when a considerable amount of heavy pulling is imposed upon the engine.

(2) Increased cylinder and ring wear. This has been found to be especially marked above dilutions of 10 to 15 per cent.

(3) Harsh running of the engine. This does not necessarily indicate excessive wear, but is nevertheless undesirable.

If internal combustion engine lubricants are to perform successfully all of the wide variety of duties imposed upon them, they must be carefully chosen so that lubrication of any particular part is not slighted. Such lubricants must be able to retain their necessary characteristics in the face of most unfavorable conditions. Furthermore, they should be protected against deleterious influences wherever practicable.

Crankcase dilution can be prevented by any of several methods being developed at the present time, and it is probable that ultimately all cars (except possibly those sold on a price basis alone) will have their engines constructed or equipped so as to protect them entirely from the dangers accompanying excessive dilution and to keep the lubricants up to the rigid purchasing specifications imposed upon them.

THE GREAT LAKES—ST. LAWRENCE RIVER SHIP CHANNEL

By CHARLES T. MAIN
Consulting Engineer, Boston, Mass.

THE Great Lakes—St. Lawrence Ship Channel, if developed, would consist of a connection between the Great Lakes and the ocean for water transportation with the incidental development of a great amount of hydroelectric power to be derived from the dams built primarily for navigation.

The scope of this project is so great and the results so far reaching that it is impossible to reach any intelligent conclusion without careful and exhaustive study, and even then the conclusions should perhaps be considered tentative as it is impossible to get all the facts entering into the problem.

The proponents are enthusiastically in favor of the project, and the objectors are able to state good reasons why it should not be carried out.

There are some basic facts upon which nearly everybody can agree, and there are certain accomplishments which are desirable if they can be obtained at reasonable expenditure.

The more I have studied the problem, the more I have become convinced that it is not capable of mathematical solution, but is largely a matter of vision and ability to foresee how the country and its commerce and industry will develop during the next twenty-five to fifty years.

The majority of the engineers who have given careful consideration to the project have decided that it is physically possible to carry out the work in some satisfactory way, the best way not having yet been determined.

I would, therefore, say that the engineering features from a physical standpoint may be assumed to be capable of satisfactory solution. Whether the project is sound economically remains to be proven.

The estimate of cost of the engineers of the International Commission increased by $20,000,000 for improving and deepening our own lake ports, and $65,000,000 for the Welland Canal for a 25-foot depth of channel and a power development of 1,464,000 H.P. is about $368,000,000.

These estimates of cost do not include the cost of transmission lines which would have to be long and very substantial.

In the limited time at their disposal the engineers could not obtain all the data for an accurate estimate of cost, and we know from experience that the actual cost of government work exceeds the preliminary estimates by a considerable amount.

The share of real cost which the United States must pay might be as much as $250,000,000, for which the United States would receive 732,000 H.P. capacity at the power station, and a waterway to the sea.

If the canalization were made for 30 feet, and the full amount of power developed, the total cost might reach one billion dollars.

It will be impossible in an article of this length to go into detailed discussion of the pros and cons of this project. I will, therefore, confine my remarks to some conclusions which have been reached.

Navigation

Much discussion has been had on the comparative cost of Lake vs. Ocean transportation. This is not the measure of cost of transportation with the proposed ship channel. The real measure is the relative cost of transporting the available merchandise for exportation and importation in ocean steamers, from and to ports on the Great Lakes and the present cost of transportation considering all the elements entering into each method. These elements with ocean steamers from the lake to the ocean are as follows: the character and quantity of the merchandise; the time required in navigating the channels and canals; the extra cost per tonnage capacity and extra cost of crews for ocean steamers; and the fact that navigating is closed for about five months of the year. The elements entering into the present methods are the cost of lake transportation, plus unloading and terminal charges at a lake port, plus railroad or barge transportation to an ocean port, plus unloading and terminal charges at an ocean port, plus reloading charges and ocean freight.

There are so many elements entering into the problem as to make it difficult to make accurate figures. I have been unable so far to make any estimates which are satisfactory but the indications are that there is not a great difference in the total cost by either method.

Perhaps the solution would be that lake steamers east bound would proceed as far as Montreal or Quebec and then reload onto ocean steamers, thus eliminating the rail charges and one reloading, and ocean steamers west bound would reload this cargo onto lake steamers at these points.

The next question is—will there be enough traffic to warrant the expenditure of the large sums required to develop this channel?

The best judge of these questions is the International Joint Commission which has collected an immense amount of data bearing upon these questions and which undoubtedly has tried in an unprejudiced manner to answer. A portion of the summary of their conclusions is as follows:

To sum up as briefly as possible its conclusions in the matter of the proposed improvement of the St. Lawrence River between Lake Ontario and Montreal, the commission finds nothing in the evidence to warrant the belief that ocean-going vessels of suitable draft could not safely navigate the waters in question as well as the entire waterway from the Gulf of St. Lawrence to the head of the Great Lakes, or that such vessels would hesitate to do so if cargoes were available.

As to the economic practicability of the waterway, the commission finds that, without considering the probability of new traffic created by the opening of a water route to the seaboard, there exists today, between the region economically tributary to the Great Lakes and overseas points as well as between the same region and the Atlantic and Pacific seaboards, a volume of outbound and inbound trade that might be reasonably expected to seek this route sufficient to justify the expense involved in its improvement.

It finds that the existing means of transportation between the tributary area in the United States and the seaboard are altogether inadequate, that the railroads have not kept pace with the needs of the country, but that this does not apply to the Canadian side of the area, where railway development is still in advance of population and production.

The solution of the problem, in the opinion of the commission, lies in the utilization of every practicable means of communication, and particularly of the wonderful natural waterway extending from the Atlantic into the very heart of the continent, together with the development of such a system of co-operation between railways and waterways as would at one and the same time bring the load the railways have to carry within practicable

limits and give the West an additional route for its foreign and coastwise trade.

The conclusion is obvious that, if countries that had for the most part to import their raw materials from abroad were able to build up a great foreign trade because of their ready access to the sea, the region economically tributary to the Great Lakes, with its limitless resources, its raw materials within easy reach, and its facilities for industrial expansion, can hardly fail to become an even greater factor in the world's markets than it is today if given a practicable and efficient water route to the sea.

Water Power

The proponents claim that the water power development will not only afford a revenue which will maintain the improvement and amortize the full cost within a reasonable period, but it will be the direct means of creating a vast industrial development which in itself will provide a large traffic on the waterway consisting of the raw materials so abundantly provided by nature in the region of the Great Lakes, and of the finished products which will be transported direct by ocean vessel to foreign and domestic markets.

The direct benefit to the East will be in the tremendous amount of water power that can be developed in connection with the building of the canal. Approximately 4,000,000 H.P. of continuous water power is said to be the amount that can be developed. About 1,500,000 H.P. of this power can be developed in the stretch from just below Ogdensburg to Lake St. Francis, or along the international boundary, and 2,500,000 H.P. in the stretch below the international boundary, or wholly in Canada.

The plans as now proposed call for a 1,500,000 H.P. water power plant to be located on the international boundary at Barnhart Island near Cornwall, Ontario. The estimated cost of this work is $253,000,000. This estimate includes only the power plant equipment but makes no provisions for the necessary transmission lines to the probable power markets. Presumably one-half of this power, or 750,000 H.P. will belong to the United States for such disposition as it may choose to make of it. The balance of the power, both developed and undeveloped, amounting to 3,250,000 H.P., will belong to Canada.

The estimate of $253,000,000 is said to be based on prices which are stated to be 80 per cent above pre-war prices. The general experience with undertakings of this kind has been that the first estimates of cost are almost invariably too low, particularly in connection with work carried out by the government. Even with large commercial undertakings the first estimates of cost are often found to be entirely inadequate, but this is not so apt to occur, except in the case of promotion schemes, as with government undertakings.

It would seem that in view of the limited time at the disposal of the engineers who made this estimate of $253,000,000 for the International Joint Commission, and our experience with other projects of a similar nature, it would be prudent to increase this figure by at least 50 per cent, to determine the probable capital cost on which to base estimates of the economical usefulness of the completed work. Such an increase would call for a capital expenditure of about $380,000,000, not including the cost of electrical equipment and transmission lines to distribute the power. To one-half of this, or $190,000,000, must be added about $75,000,000 for the transmission and distribution of the 750,000 H.P. to which the United States is presumably entitled. Our share of the total cost would then be about $265,000,000, assuming that each of the two interested countries pays one-half of the cost.

The Commissioners have recommended:

(9) That "power works" be built, installed, and operated by and at the expense of the country in which they are located.

(10) That except as set forth in recommendation (11), the cost of all "navigation works" be apportioned between the two countries on the basis of the benefits each will receive from the new water way:—"

(11) That the cost of "navigation works" for the combined use of navigation and power over and above the cost of works necessary for navigation alone should be apportioned equally between the two countries.

If carried out, this would make the portion to be paid by the United States more than one-half the total.

These figures do not include the $50,000,000 required for interlake channel improvements and harbor improvements or any portion of the $65,000,000 required for the Welland Canal. None of these, however, should be charged to power.

This 750,000 H.P. transmitted to New England and New York State would amount to about 450,000 Kw. ready for distribution and not over 400,000 Kw. at the switchboards of the industries using the power.

It would not be practicable to so connect the transmission lines from the St. Lawrence power as to make full use of all the power that could be generated for some time to come without going to prohibitive expense. It would be safe to assume that not over three-quarters of the power available could be used throughout each 24 hours of the day in the beginning at least. 400,000 Kw. output at 75 per cent load factor is equivalent to about 2,630,000,000 Kw. hrs. in a year. If the total yearly cost is $28,000,000, the cost per Kw. hr. would be 10.6 mills or just over one cent.

There should be no difficulty in absorbing this amount of power by the industries, public service utilities and railroads, since it is estimated that the power consumption in New England and Northeastern New York State is more than this amount at the present time and will probably be 7,000,000,000 Kw. hrs. by 1930.

In charging the power with $28,000,000 yearly expense we assume that it will have to bear the full fixed and operation charges on the entire investment, both for canals and power development, and this is most likely to happen.

All things considered, it would seem that from a power standpoint alone this St. Lawrence development may prove to be economically sound. With the increased cost of coal and the increasing demand for it, our industries will probably never again be able to produce or purchase power for a figure which is not considerably in excess of one cent per Kw. hr.

The real question is—will the development of navigation and water power on the St. Lawrence River be sufficiently beneficial to the country as a whole, to New England and to Massachusetts to warrant the large expenditures necessary?

Under the adverse conditions already described to shipping it is probable that for some time to come there will not be enough shipping to make a fair return on the expenditure required for navigation and there may, therefore, be some disappointment to the Middle West, but no one can predict what developments in the future in such a country as ours will bring about, and it is probable that some time in the future this development will be of value to the Middle West and to a large part of the country.

The Manchester Ship Canal is an example of a development of vital importance to the business of Manchester which for several years did not pay dividends but which now is on a paying basis.

(*Continued on page 228*)

MONTHLY NEWS

First All-Metal Naval Plane. The Navy's first all-metal airplane has been completed and has undergone preliminary trials at Garden City, L. I. It is a fighting plane, known as the F4C, convertible for use either as a landplane or as a seaplane. The plane is almost entirely constructed of specially-treated duralumin. One unusual feature is the use of special fasteners for the canvas covering that is over the metal framework of the plane. These fasteners permit access to the inner structure of the plane at any point, thus eliminating the necessity of damaging the outer cover when it is desired to inspect or repair the structural work.

The use of duralumin instead of the conventional wood gives a saving in weight which allows a very much improved performance, including greater air speed, faster climb, and lower landing speed.

The plane is powered with a Wright J1 (Wright-Whirlwind 1), 200 H.P. air-cooled engine and has a designed speed of approximately 130 miles an hour.—*Aviation.*

Testing Test Machines. A spring balance in which the "spring" consists of a solid metal bar over an inch in diameter is used by the Bureau of Standards as an aid in calibrating testing machines. Contrary to the usual custom, it is the "spring" that is to be tested, the weights being known to a few hundredths of a pound. This bar is tested under various loads up to 100,000 pounds and its change in length for each load is measured with an extensometer. It can then be put into a testing machine, and by noting the readings of the extensometer, the force being applied by the machine can be measured and compared with the machine's own readings, in much the same way as the accuracy of a scale is checked with standard weights.

The balance for testing this calibration bar consists of a lever resting on the top of a short column and having a pan at its long end into which weights up to a total of 35,000 pounds can be put. The calibration bar is attached at the short end, and the ratio of the lever arms is such that loads up to 100,000 pounds can be applied to the bar. Bars for calibrating the compressive forces exerted by testing machines can also be tested in this balance. They are placed between two interlocking yokes and these are attached to the lever and to the base the same as the tensile bars.—*Engineers and Engineering.*

Largest Paddle Steamers. The sister ships *Greater Buffalo* and *Greater Detroit*, recently completed at the plant of the American Ship Building Company, Cleveland, Ohio, are the largest vessels as yet constructed to be propelled by paddle-wheels alone. The famous *Great Eastern* exceeded them in size, but was also provided with a screw propeller.

These fine ships have been constructed to the order of the Detroit and Cleveland Navigation Company for passenger service between Detroit and Buffalo.

The principal dimensions are as follows:

Length overall	535 ft.
Beam molded	58 ft.
Beam extreme	96 ft. 6 in.
Depth molded	23 ft. 7 in.

Construction is of steel with transverse framing and a complete double bottom extending all fore and aft. Propelling machinery consists of 3-cylinder compound inclined engine developing 12,000 I.H.P. and driving feathering side-paddle wheels, giving the ships a speed of twenty-one miles per hour. Passenger accommodations are luxuriously decorated and fitted up.—*Marine Engineering and Shipping Age.*

Ford's Railroad Electrification. The Detroit, Toledo and Ironton electrification is very different from previous electrification practice. The trolley voltage adopted, 22,000 volts, 25 cycles, a.c., is twice as high as any previously adopted in this country. Regenerative braking will be a feature. The current will be taken from the line through an oil circuit breaker to a transformer, then to a motor-generator set. This set will consist of a 2,100 h.p., 25-cycle, four-pole, single-phase motor, driving a 1,500-kw., 600-volt, 2,500 ampere generator at 750 r.p.m. A 75-kw., 126 volt, d.c. "main exciter" will be mounted directly on a shaft extension at the motor end, while a 25-k.w., d.c. "regenerative exciter" will be mounted directly upon a shaft extension at the other end.

The generator will be provided with series excited differential field, interpole field and compensating field as well as a separately-excited field.

The locomotive traction motors will be 225 h.p., 600-volt, d.c., series, axle-hung machines, each flexible coupled to a driving axle by double gearing, that is, a gear at each side.

Each two-unit locomotive will develop a maximum of 5,000 h.p., at seventeen miles per hour, and will exert a maximum starting tractive effort of 225,000 pounds, on the basis of 42,500 pounds axle loading with 33 1/3 per cent adhesion. The nominal rating will be 4,200 h.p It will deliver 3,600 h.p. at all speeds up to seventeen miles per hour.

Each motive power unit will be arranged for double-end operation so that an operating locomotive may consist of either one, two or more units as desired.—*Electric Traction.*

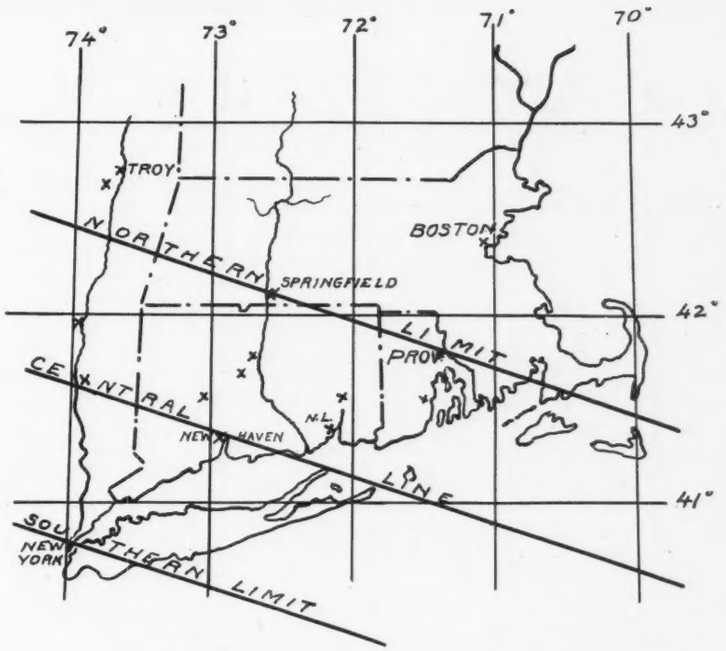
Growing Australian Air Mail Service. The long deferred air mail service between Adelaide and Sydney was inaugurated early in June, 1924, by a Melbourne company subsidized by the Commonwealth Government to the extent of £19,000 for an initial period of twelve months from the date of the commencement of the service. After the first week, passengers were carried in addition to mail. Later the service is to be extended to Brisbane, when the subsidy will be increased to £27,000 per annum.

The rate of postage was fixed at 3d. for each half ounce, in addition to the ordinary postage rate, and letters must be specially indorsed "per aerial mail." The intermediate stopping places are Mildura, Hay Narrandera and Cootamundra; the complete time of each journey eastward is 24½ hours, and of each westward flight, 24 hours.

This brings the total mileage of organized routes of regular Australian aerial transport facilities up to 2,809 miles. These services are all flown weekly and involve flights totaling 292,136 miles each year.—*Aviation.*

The Total Eclipse of the Sun of January 24, 1924. The total eclipse of the sun which will occur on the morning of January 24 (Saturday) will be visible, weather permitting, along a track about 110 miles wide and whose central line passes near to New Haven and Montauk Point. At New Haven the period of totality begins at 9h. 11m. 47.9s. A.M., Eastern Standard Time, and lasts for about two minutes. For other places the time varies only a few minutes. The phenomena naturally looked for with great interest are the solar prominences, near the edge of the disc, and the corona, which reaches out for some distance from the sun, but which is so faint that it is not seen to advantage if the observer's eyes are fatigued by watching the oncoming eclipse. The best result is obtained by shielding the eyes from bright light until totality begins. About 30° to the right of the sun will be seen in a group the three planets, Mercury, Venus and Jupiter.

GEORGE L. HOSMER, '97.



AREA AFFECTED BY TOTAL ECLIPSE OF SUN

Promising Substitute for Platinum. The collapse of Russia's platinum production since the beginning of the world war has caused great scarcity of this precious metal and has made it so costly that the chemical, metallurgical and other industries which require large quantities of platinum in the form of crucibles, retorts, evaporating dishes, tubes and other apparatus, were compelled to look for substitutes, cheaper and more easily obtainable, even if inferior in some respects to platinum.

One of the most promising substitutes recently found seems to be iron oxide. The oxide, which must be chemically pure, is obtained by blowing highly compressed air through molten iron from which all impurities, particularly sulphur and phosphorus and their compounds, have previously been removed. This pure oxide can be melted at a high temperature and cast in molds. The roughly cast parts can easily be machined, are hard and take a smooth finish. The cost is extremely low compared with that of platinum and even lower than that of other substitutes, like porcelain and quartz. The material is not attacked by acids or alkalies even at high temperatures and is therefore suitable for use in the manufacture of many salts and other organic or inorganic compounds.

The new material promises to come into general use in the metallurgical and chemical industries in view of its valuable qualities and of the fact that the cost of platinum will probably remain prohibitive for many years to come, perhaps forever. — *Scientific American.*

German Turbine Locomotive. The first condensing turbine locomotive in Germany has recently been completed at the Krupp Works at Essen. In its outline, the engine resembles the ordinary design of steam locomotive, the turbines and transmission gearing being placed at the front end. Two turbines are provided—one for ahead running and one for backward—arranged in separate casings on either side of the transmission mechanism. They are of the Zoelly type and develop 2,000 h.p. at a speed of 6,800 r.p.m. or 80 km. per hour. Both turbines are connected by a helical toothed shaft which gears through an intermediate shaft with a jack shaft over the coupled axles. Power is finally transmitted to the driving wheel by means of connecting rods operated by cranks on the end of the jack shaft.

The turbines deliver their exhaust steam into the first of two cylindrical condensers and then through connecting pipes to the second, from which the condensed water is pumped to the boiler. The condensers are arranged transversely beneath the boiler immediately behind the turbines. An auxiliary or pilot turbine taking steam direct from the boiler and discharging to the condensers operates the feed pump, circulating water pump and air compressor. A feed pre-heater is also provided. Cooling chambers for the circulating water are arranged on the tender. Air is drawn through the cooling chambers by a rotary fan which also assists in drawing in the circulating water. The chambers contain grids carrying a large number of metal rings through which the water drips and in this manner is quickly cooled. Flexible pipes connecting between engine and tender complete the circuit of the cooling water.

The boiler is of orthodox locomotive design, carrying a working pressure of 185 lbs. per sq. in. A superheater is provided. A turbine driven fan supplies forced draught to the firebox.

Trials made so far demonstrate marked thermal and mechanical advantages over the reciprocating locomotive. A further series of special tests is to be carried out.—*The Locomotive, London.*

A New Method of Submarine Pile Driving has recently been developed which is a radical departure from the older practice. The hammer employed is so arranged that compressed air at low pressure is supplied to a bottom cylinder by means of an air hose connected at the hand-hole cover. Either steam or compressed air may be used for motive power; and the exhaust from the pile hammer is carried to the surface through a hose. The bottom cylinder, into which the compressed air is introduced, is not intended to be water-tight. It is supposed to function on the principle of the diving bell—that is, the water is kept out of it by the counter pressure of the compressed air. As this new type of hammer uses piles cut to size, it makes it possible to drive them to exact grade, and thus obviates the work of sawing off any excess lengths under water.—*Comp. Air Mag.—Abstracted by Scientific American.*

RECENT BOOKS

A Popular History of American Invention, by Waldemar Kaempffert, 2 vols., Scribners, New York, 1924, pp. 1034.

"Daddy, does God turn a pitcher upside down when it rains?" Whereupon the young scientist is accompanied into the kitchen and with the assistance of a tea-kettle instructed in the ways of water vapor.

Unfortunately, one cannot always answer questions so easily, particularly when the origin and history of our American inventions is the subject of inquiry. It is then, as well as in those moments when we wish to nourish our own desires for general information, that *A Popular History of American Invention,* edited by Waldemar Kaempffert, becomes a valuable reference. There are two profusely illustrated volumes, the first devoted to transportation communication and power; the second dealing with material resources and labor-saving machines.

In most respects the books are remarkably complete, though it seems strange that such epoch-making American inventions as the *Monitor* and the submarine should receive no attention. The scientific housewife would be disappointed in her search for an account of what American inventors have done in developing her vacuum cleaner, but this regret would soon be forgotten in her eagerness to read of how the "movie" she saw last evening was made.

It is not written in the monotonous style of an encyclopedia, reciting many facts, but the story is clothed with flesh and blood by the inclusion of choice bits of conversation and many amusing anecdotes. For instance, our housewife sympathizes with Wm. S. Hart, who was accidentally floored with a real crockery vase instead of the papier-mache one, and her automatic telephone takes on new realism as she reads that its invention was begun thirty years ago by a Kansas City undertaker who was obsessed with the idea that the local operator was in conspiracy with a competitor to ruin his business by falsely reporting his line "busy." The 1925 model would say, "He don't answer."

With excellent type; for the most part well written, though in spots a bit too technical for popular consumption; abundant in interesting information of the struggles, the failures, and the final victories of American Genius, these two volumes are well worth spending a few hours with.

It is astonishing how often the man who analyzes his work stumbles on an invention when he is looking for something else.

F. ALEXANDER MAGOUN.

Eye Hazards in Industrial Occupations, by Louis Resnick and L. H. Carris. National Committee for the Prevention of Blindness. New York, 1924, 247 pages.

This volume is a reconstruction of an earlier publication by the same society. It is a compilation of the findings of several organizations as well as many safety engineers working in the field of eye hazards. The composite nature of the material and the many illustrations should make it a very useful reference book for safety engineers and executives.

The authors recommend the revision, by careful application of engineering principles, of the processes and machines used in manufacturing so as to eliminate or reduce the hazards incident to the present systems. Until this is universally possible, shields, goggles, masks, screens and other protective devices must be used.

The subject matter may be divided into two almost distinct types. First, the specific hazards are grouped according to the causative factor and a method for protection is suggested in each case. The protective devices suggested are in use in some plant and have given satisfactory results.

In the more general chapters, the needs for protection and the methods of educating workers to protect themselves are outlined. These chapters include the personal experiences of several pioneer safety engineers and their clever schemes to get the workers' co-operation would be invaluable in starting a campaign for eye protection.

A very extensive reference list of publications, dealing with particular phases of eye hazards, diseases, etc., is included in the volume.

PHILIP K. BATES, '24.

GENERAL SCIENCE

Matter and Change: an Introduction to Physical and Chemical Science. By W. C. D. Whetham. Cambridge, Eng.: University Press, 1924. 280 p.

Dr. Whetham might be described as an English Slosson, presenting scientific discoveries to the general reader in understandable form. He believes, however, that "it is better to gain the spirit of scientific method, or even to understand it, than to acquire a superficial knowledge of results"; hence his method is to trace the gradual development of discovery in each field, from underlying facts through patient research to results. Chapter subjects are: Matter, dynamics, heat and energy, electricity, chemical action, organic and bio-chemistry, waves, radio-activity, astro-physics.

CHEMICAL ENGINEERING

Sugar Machinery: a Descriptive Treatise. By A. J. Wallis-Tayler. London: Wm. Rider & Son, 1924. 410 p.

This volume is based upon an earlier work published some years ago by the same author. It deals not only with sugar machinery but with the complete layout of sugar-cane factories and with the processes of manufacture of both cane and beet sugar.

FUELS

Report of the Empire Motor Fuels Committee: Embodying other Allied Researches. London: Institution of Automobile Engineers [1924]. 352 p.

The above-named committee was set up by the Imperial Motor Transport Council in 1920 to encourage the production and utilization of new motor fuel supplies, and was aided financially by various technical societies. Its report, published as Vol. 18, Part 1, of the Proceedings of the Institution of Automobile Engineers, deals mainly with the results of tests of ethyl alcohol, 95, 90 and 99 vol. per cent, and of alcohol-ether mixtures, but is augmented by the inclusion of papers contributed by various other investigators. One of these latter is a note on the work of Midgely and Boyd in this country, and another a note on the solubility relations and other properties of mixed fuels.

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ANALYTICAL CHEMISTRY AND THE STUDENT

(*Continued from page 207*)

enable him to carry on his work successfully when he finally goes forth as a chemist.

As has been intimated, quantitative analysis is the means through which chemical science has advanced to its present wonderful state of development. Science becomes exact only when quantitative measurements are made. Theories may be tested and checked only by precise measurements. Quantitative analysis has served to tell us the composition of all substances found in nature or made by man, and allowed us to classify them and their constituent elements. From these classifications we have been able to derive many of our useful laws and theories. Much of chemistry has to do also with changes of matter by reactions, or thermal or electrical changes.

How do we know what these changes are and how they progress? By following their course by means of quantitative analyses. The great structure theory underlying organic chemistry, the laws of chemical equilibrium, electrolysis, catalysis, etc., have all required quantitative analysis for their demonstration. How are the text books able to tell us what the products of certain oxidations, reductions, metatheses, are? Because investigators have found out by analysis. We know that basic zinc carbonate precipitates when sodium carbonate is added to a solution of zinc salt, only because someone has carefully analyzed the precipitate. We know that certain reddish earths are valuable for iron, because someone has analyzed them. We know what the proper healthy condition of the blood should be, thanks to investigators who have analyzed it under all sorts of conditions.

Quantitative analysis does more than classify substances and check up theories. It has led directly to the formation of new check-up theories. It has led directly to the formation of new theories, and has caused discoveries which today are making profound changes in the whole ground work of chemical theory. Analytical work first led to filling in the gaps in the Periodic Table, and acquainted us with radioactive elements. These in turn led to our present knowledge of radio-chemistry and the electron theory. Work on isotopes, and positive ray analysis are samples of what is being demanded of quantitative analysis today for the advancement of chemical science.

Besides serving sciences other than chemical by doing control work in almost all branches,—metallurgy, medicine, agriculture, etc., — quantitative analysis is an indispensable tool of industry and commerce. It is used for determination and control of factory intake and output. Analysis of all raw and finished products is common practice today in almost every line; it insures uniformity and maintenance of standard. Sales or purchases are made on specifications, depending on analysis.

The operation of processes; improvement of products, duplication of samples, settlement of legal cases, all need competent analysts.

The government uses a large staff of chemists in quantitative analytical work. The Bureau of Standards, the Bureau of Mines, Pure Food and Drug Bureau, Federal Trade Commission, Tariff Commission, Patent Office, Forestry Service, Chemical Warfare Service, Ordnance Department, and others, all carry on chemical work in the promotion or regulation of the country's welfare; much of it is carried on by analytical chemists, who are creating standards for various commodities, checking the conformity of products to existing standards, searching for new uses for our natural resources, testing dutiable imports, analyzing and testing new products developed for use in medicine, warfare or agriculture.

A technically trained young man going into a business,—tanning, dyeing, metallurgy, brick or paper or paint-making, or whatever it may be, will have, if alert, chances to improve process or product. That is what he is there for. His progress is rapid if he can see and institute improvements. But to figure out these improvements and get them going will require tests. And inevitably tests mean reliable analyses—whether on fuel saving, reclamation of waste liquors, utilization of spent tan bark, improvement of clay mixture, introduction of a new pulp bleach or a better pigment mixture, or whatever it is,—quantitative data must be obtained as a basis for any figuring, first to prove the points to himself, and next to demonstrate them to his employer.

How is he going to make these tests and get his quantitative chemical data? Call in an analyst? And share the glory and profit? Not much! It is up to him to turn out some good quantitative analyses, and get the right results without having some one to check the figures over for him. This is not difficult to one who has had good training as a student.

True, the practice of quantitative analyses is not the supreme height a chemist may attain. But as a rule, he cannot reach the eminence of scientist, chief chemist, factory manager, or consulting expert, without having first learned to do this ground work well. In industry the rule prevails that a man must come up through the ranks. The place most often open to young chemists, is a job in a works control laboratory,—and there he must do analyses. And he must do them well if he is to be promoted to the next step,—generally charge of some unit process of the plant. For this analytical work will develop more than mere ability to report per cent of so and so. It gives a good practical insight into the working of chemical laws, teaches general chemistry, trains in planning out work for speed and accuracy, shows the value of neatness and system, makes skillful and resourceful manipulators, and gives practice in using the mind in figuring out an attack on a new problem.

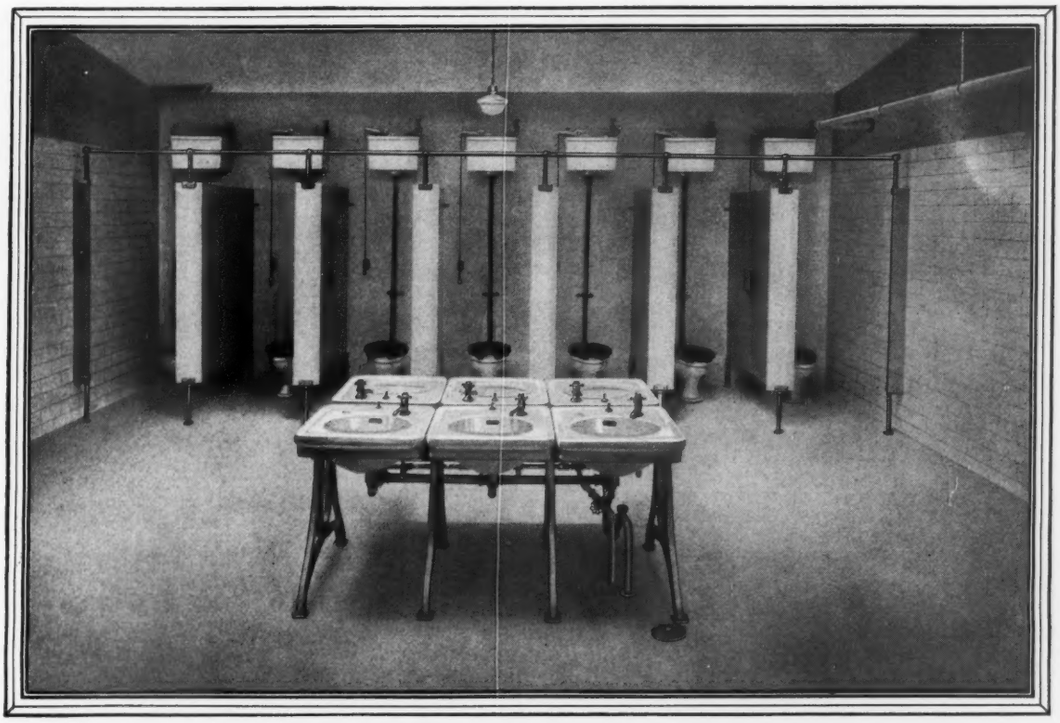
Suppose a chemical product you were putting out suddenly went off-color. How would you remedy the difficulty? Probably by analyzing to see what impurity caused the change, and then analyzing the different raw materials to see where the source of contamination lay.

Suppose a competitor brought out a product a little better than yours. You would certainly have to analyze it at once to see what he had in it,—unless he would be so gracious as to tell you.

A charge is to be made up for a smelting furnace. Ore, flux and fuel must be analyzed in order that they may be fed in in the correct proportions.

A plant making phosphates for the fertilizer trade, decides to enter the drug and pharmaceutical field, and produce the very high-grade phosphate salts used there. At once its chemists must devise and put into effect testing methods which can be used in making sure the various salts are refined to the state of purity demanded by this trade.

Such problems as the above will come to every chemist. He will not, as a rule, find the whole answer in a book. It is his experience and ingenuity he must draw on. It is in preparation for this that the student work in quantitative analysis is laid out. Look for its applications, learn the chemistry it teaches, realize its value, take pride in being a good analyst. It is a tool that will serve you well.



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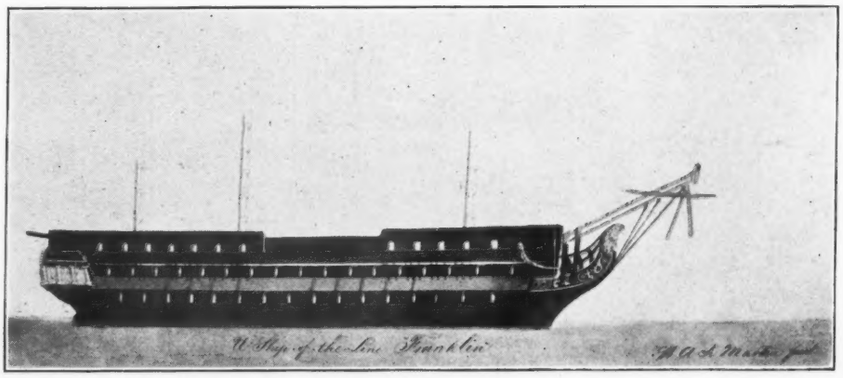
TECH'S AUXILIARY FLEET

(*Continued from page 210*)

course, of recent coinage; yet, the *Great Harry* was a bulwark of the Realm in her day, and might easily be called England's "capital ship" of that day.

One could fill page after page with interesting historical incidents of the kind here described, without sounding the depths of this collection. But one more print will therefore be referred to. "Le Barge remontant le Mississippi, largue." This view, one of A. St. Aulaire's, was drawn in 1832. Foreign students who desire to get correct local color after viewing the print, should read Mark Twain's "Huckleberry Finn." This is a very humorous tale, yet withal one that gives much information about traffic on the great Mississippi during slavery days.

Students of engineering subjects during their spare moments ought to acquire information concerning the early practices of the torch bearers in their chosen profession, and also give attention to the history of their native country. There is no better nor more interesting way to become informed on history than by familiarizing oneself with the exploits of one's naval and merchant marine, as told by biography, picture and print. There is scarcely a technical profession taught at this Institute about which one cannot find much of this kind of information. For instance, students in Naval Architecture are counseled to read "Ships and Ways of Other Days" and "Wooden Ships and Iron Men."



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This short account of "Tech's Auxiliary Paper Navy" carries with it the writer's hope that it —but more particularly the collection itself—will serve to keep green the memory of the achievements of our clipper ships, early steam packets and the navy of our forefathers, and recall often to mind the names and heroic deeds of the men who sailed, manned and commanded them.

In the New Year now before us, and during those to follow, let everyone give a "strong pull" for *Our Navy*.

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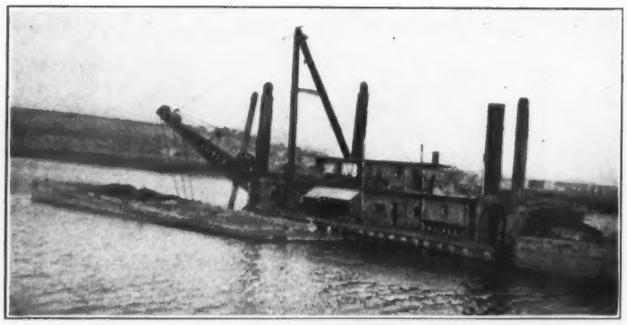

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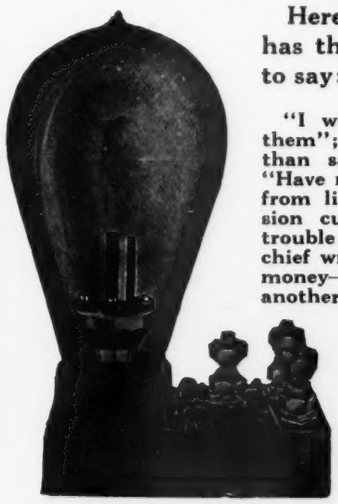

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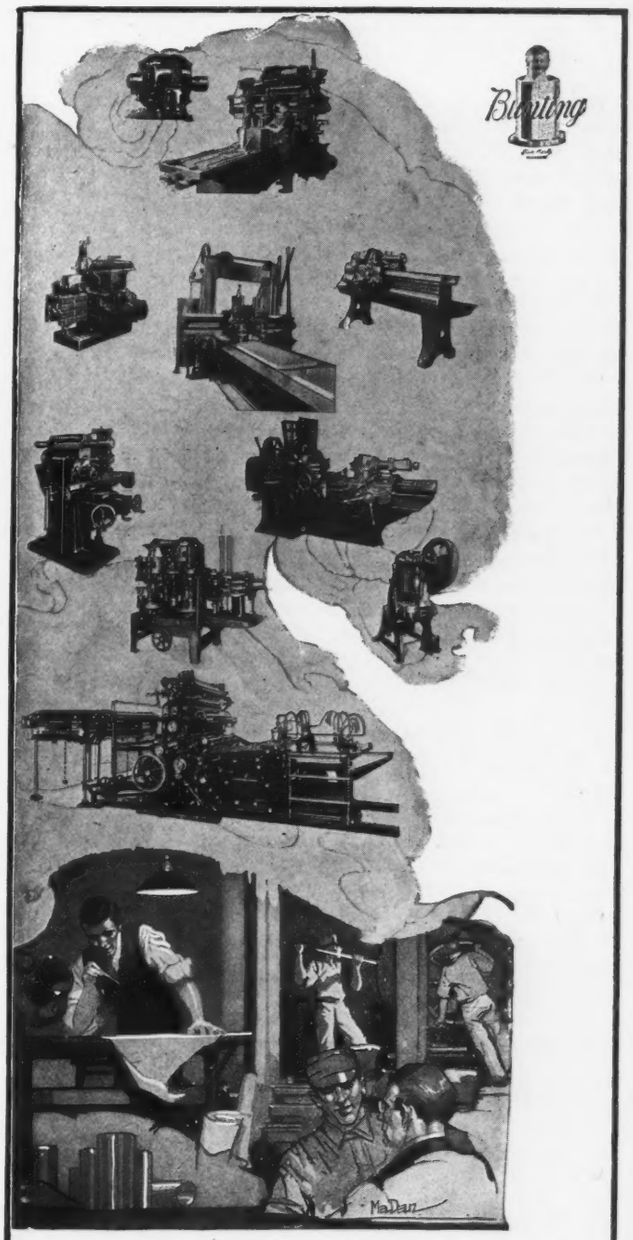

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GREAT LAKES—ST. LAWRENCE RIVER SHIP CHANNEL

(*Continued from page 219*)

With railroad connections to Ogdensburg, the most of New England will probably be benefited rather than injured by the development of navigation.

The development of water power will not directly benefit the rest of the country outside of New York and New England except that prosperity in one section is of some benefit to the whole country.

There is a direct benefit to the whole country, however, in any undertaking which lessens the consumption and tends to conserve our other natural resources usable for power, viz., coal and oil.

What are the probabilities that we will suffer serious loss if the St. Lawrence water way is constructed?

New York, Pennsylvania and Massachusetts pay 43 per cent of all the taxes and if this development which is of doubtful value to these states is to be paid for from taxes, we should have good reason to oppose it, particularly considering the immediate future.

If the propect is financed by an issue of bonds and properly amortized, our objection would largely disappear even though we would have to pay the total cost through our use of the power, provided the cost of the power is reasonable.

The other important point to be considered is the effect of this proposed waterway on the New England ports and railways. Although it seems doubtful that shipping of any importance could be developed between the port of Boston and Great Lakes ports, it may be possible at least to the extent that we now have coastwise shipping. Since freight from interior New England to the Great Lakes ports would have to travel only a short distance farther by rail to reach Ogdensburg, N. Y., from whence the water distance would be very much shorter than from Boston, it is evident that freight other than from very near Boston would not utilize the St. Lawrence waterways.

It is conceivable that through the use of the St. Lawrence water power our industries will find themselves able to expand to such an extent that the additional products resulting therefrom will be the real solution which will provide the needed traffic for our ports and railroads.

Seventy per cent of the potential water power of the country is west of the Mississippi River. Outside of the State of Maine there is very little undeveloped water power in New England. The laws of Maine do not permit its water power to be transmitted outside of its boundaries. New England's industrial supremacy may, therefore, well feel itself threatened by its lack of water power, in view of the constantly-increased cost of coal.

Taking into account all of the facts now obtainable about the projects, the fact that the Joint International Commission has reported favorably, and that many states are urging favorable action, it would seem to be almost impossible to stop favorable legislation even if we disapprove of it, provided that treaties are made between the United States and Canada which will properly protect our interests, and provided that the further studies of the engineering and economic features, which are now being made, are favorable to the project.

Considering the project in the broadest manner, it would seem as if the discussion of all details might be eliminated. This country is bound to grow. Its transportation facilities are now sometimes taxed to the limit. The development of navigation will add one more facility. More power at moderate prices will be required. The development of the water power will furnish a large amount of such power. By the time the development is completed, the country will be ready to use it.

German Steel Industry. Conditions in the iron and steel industry are further improving and most of the blast furnaces that were blown out during the summer have been rekindled. The ore mines are not yet in full working order and the producers find it increasingly difficult to compete against the better foreign ore. The steel works are also encountering a strong opposition from abroad, but business in rolled material has become brisk and the iron works are having a boom at present. Some of them are even declining further orders as they are fully booked for some time, both for home and foreign account.—*The Iron age.*

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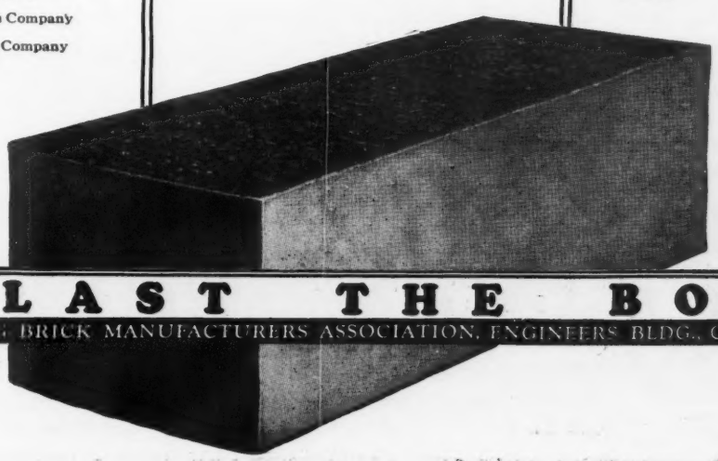

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OREBODIES

(*Continued from page 215*)

perature. Probably there are some that would say that the force of gravity has no horizontal component. Professor Eotvos will tell you differently. I am afraid I have already exceeded my space, and I would dislike to close this article with differential equations so I shall refer those thirsting for knowledge to an article on the subject by Stephen Rynar in Economic Geology, volume 18, 1923.

As time goes by and the treasures of the earth are becoming exhausted we shall probably, more and more, need this as well as the other methods, here described, to locate buried treasure.

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FAILURE OF METAL SURFACES

(*Continued from page 205*)

the pinion when replacement becomes necessary. However, when defectively mounted, the pinion is apt to get loose on its shaft while in service. The mounting of the pinions for motors in railway service is usually made by repair shop mechanics generally unaware of the necessity of careful mounting. It has been found that the mounting had been done by putting the pinion into a forge oven, sliding it on the shaft and driving it by means of a heavy sledge-hammer as far as possible on the tapered shaft. The mechanic then felt satisfied that he would never again encounter the trouble of a pinion getting loose from the shaft. However, what is the effect of the stresses set up by such an abnormal mounting going to be on the service strength of the pinion?

When examining under polarized light the celluloid models of the pinions after they are shrunk on their shaft, it was shown that the maximum stress occurred at the points where the radial lines passing through the middle of the teeth cross the bore—the dangerous section occurring along this radius.

Mechanical tests on steel pinions were made subsequent to these photoelastic tests, forcing tapered plug into the tapered bore. Fig. 1 is a photograph of the ruptured pinions. They present ruptures which would have been entirely unsuspected before photoelastic analysis but are a remarkable verification of it.

The photoelastic analysis also revealed that the sections of dangerous stresses are different for different values of the radial pressure and the applied torque load, and that as a result of highly localized stresses, a pinion under a high radial pressure and normal torque load would fracture as shown in Fig. 2, with a V-shape. The V would become deeper and sharper as the radial pressure increased until, as a limiting case, with maximum radial pressure and no torque, an approximately straight radial crack is obtained as shown in Fig. 1.

Service fractures show, as expected after such an investigation, all degrees of angularity, from the flat break with low mounting stresses, to the very sharp angle of highly stressed pinions. As an example, Fig. 3 shows the result of a mounting stress so high as to nearly burst the pinion which with light torque was soon fatigued in operation.

The investigation, of which we have here brought up a few salient points, shows how the causes and responsibilities of failure may be traced. It is also one of the many possible illustrations of physics at the service of engineering.

We might mention that several important investigations are in progress at present in our laboratory of photoelasticity, among which we are permitted to mention the study of the stresses in rigid airships and the study of the dynamic stresses in rapidly rotating gear pinions.

New Swedish Direct Electric Steel Process. Based upon tests which are reported to have been made on a large scale at the Hagfors Iron Works, Uddeholm Co., Sweden, the announcement is made of a new direct method of making steel from iron ore. The new process has been invented by a Swedish engineer, G. H. Flodin, for years associated with De Laval, inventor of the turbine which bears his name. The process is described as a one reduction electric process in which, by means of a scientifically balanced charge, low carbon high-grade steel as low as 0.10 per cent carbon, can be produced direct from iron ore. Details concerning the process are not yet available, but it is said to be conducted in a new type of electric furnace developed by the inventor. That ferro-alloys, stainless iron and other products can be produced in this furnace direct from ore is also claimed.—*Iron Age.*

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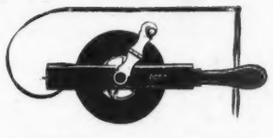

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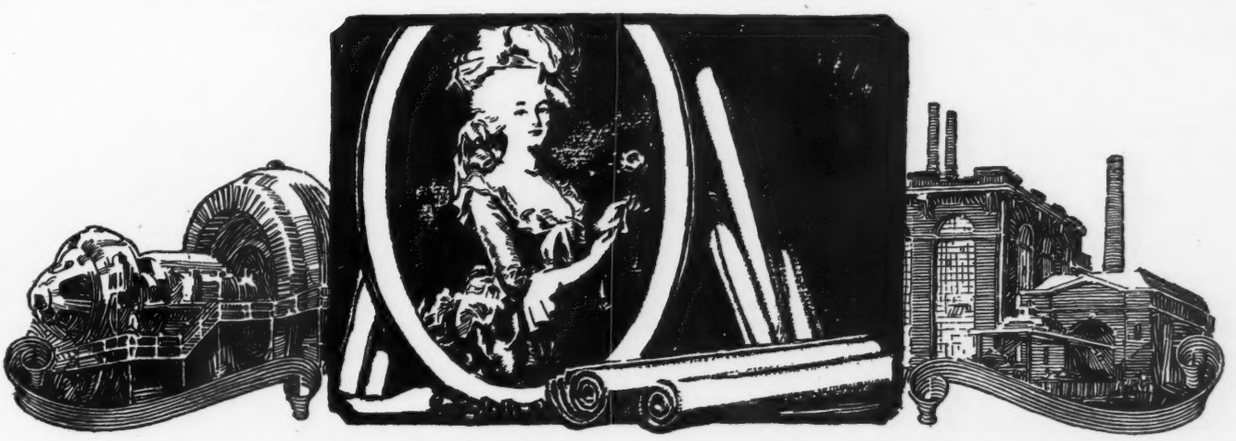

ART PRINTS AND BLUE PRINTS

Painters, authors, and musicians win fame and fortune by transmitting their conceptions to paper. Achievement can be completed merely with such expression of an idea. Not so with engineering. The design of a turbine or of a flat iron, once it is created, is not placed upon a pedestal in a millionaire's mansion, or in an art museum. It immediately goes into the shop—there to be executed. Its success is measured by the degree to which it fits manufacturing requirements. If it can't be manufactured economically it is a failure.

In an organization like Westinghouse there is a group of engineers whose chief interest and concern is the efficient, economical, large scale manufacture of electrical products. These men may be electrical engineers or mechanical engineers. They are primarily interested in shop practice and methods—in the same industrial problems as are the manufacturing customers whom Westinghouse serves.

The founder of Westinghouse was such an engineer. He possessed a marvelous faculty to inspire workmen and executives alike; there are many tales of men working nights and Sundays to help him complete a cherished plan.

Throughout all industry there is a call for men qualified as manufacturing engineers who can combine materials, machines, men, and methods with better and more efficient results.

Such men find pleasure and inspiration at Westinghouse—developing apparatus to help other manufacturing executives solve similar problems in every kind of industry.

This advertisement is fifth in a vocational series, outlining the fields for engineering achievement in the Westinghouse organization. Copies of the entire series will be sent to anyone requesting it.

Westinghouse

ACHIEVEMENT & OPPORTUNITY

W
WESTINGHOUSE ELECTRIC

PATENT ENGINEERING—A COMING PROFESSION

(*Continued from page 211*)

halves of the cam could be removed. It was possible to do in five minutes what had formerly required from two to four hours. This was an unforeseen by-product of the desire to find "another way."

It is only with the assistance of a person who has an equally good grasp both of mechanical laws and of patent laws, that an entirely new principle can be adequately protected.

For example, one large manufacturer of textile machinery developed the automatic loom, and being a pioneer in this field, proceeded to apply for and obtain what he then believed to be a basic patent. This patent was confined, however, to automatic means for changing the bobbin (or spool) which carried the yarn or "filling." Soon afterwards a competing manufacturer of looms devised and patented an automatic loom which changed not only the bobbin (or spool) but the entire shuttle which carried the bobbin to and fro. Neither the original inventors, nor the manufacturers, nor their patent attorneys had the combination of legal and mechanical knowledge to foresee and forestall this, and as a result the competitor evaded the claims of the so-called "basic" patent.

To conclude, it is generally conceded that this age is the age of the science of mechanics. It is also the age of legal restrictions and of increasing complexity.

Biologists have told us that the need of a certain function develops that function. Economists have told us that demand creates the supply.

Somewhere, somehow, sometime, in the not far distant future, twentieth century civilization will train, develop and learn to appreciate the Patent Engineer.

Dynamo Electric Machinery, by Erish Hausmann: D. Van Nostrand, New York, 1924, 634 pp.

A very complete treatise on the general theory of electrical machinery, with many illustrations and data on their practical use.

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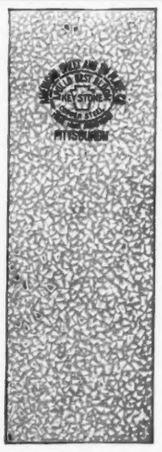
We manufacture SHEET AND TIN MILL PRODUCTS for all purposes—American Bessemer, and American Open Hearth Steel Sheets, Keystone Copper Steel *rust-resisting* Sheets, Apollo Galvanized Sheets, Formed Roofing and Siding Products, Culvert and Flume Stock. Sheets for Special Purposes, Roofing Tin Plates, Bright Tin Plate, Black Plate, Etc.



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DAYLIGHT ILLUMINATION.

The angle of refraction being equal to the angle of incident, it is a simple matter to determine the correct angles to use in manufacturing glass which will give good illumination. But for proper industrial plant illumination, there is more to be considered than mere deflection of light. The direct beam of light must be eliminated in order to prevent sun glare, which is objectionable on account of its causing heavy shadows and strong contrasts which decrease the efficiency of employees and necessitate the use of shades which in turn reduce the light to such an extent that daylight illumination any distance from the light source is not sufficient. Therefore, in order to produce a glass which when used in the windows of industrial plants will produce as near to ideal illumination as possible, we must first eliminate the direct rays of the sun by deflecting the light to the ceiling and side walls which re-deflect it back to a distance 25 to 50 feet from the window throughout the entire working area. To accomplish this we have scientifically designed a type of glass which is named "Factrolite."

Factrolite consists of 30 ribs to the inch, running at right angles, forming 900 pyramidical prisms or 3,600 light deflecting surfaces which completely disintegrate the direct beam of light from the sun. Furthermore, the depressions in the surface of Factrolite are so slight that the accumulation of dirt and dust is minimized and can be perfectly cleaned with an ordinary dry scrubbing brush. Incidentally, the cleaning of windows is most important for keeping up production and increasing the efficiency of any industrial plant and should be given more consideration in plant management.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

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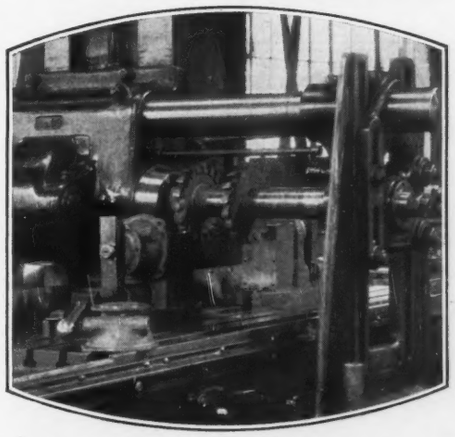

Straddle Milling Universal Joint Housings

ARCHITECTURAL ACOUSTICS

(*Continued from page 213*)

both, an intermediate volume should be chosen. Theoretically, the energy of the source of sound varies with the square of the cube root of the volume. An experimental relation is shown in Fig 2.[3]

The second factor is the shape and position of the walls. These should be arranged to minimize echoes. Plain rectangular walls are preferable; curved walls and domes are often faulty.

The third important factor is reverberation; that is, the amount of absorbing material which will reduce the time of reverberation to a suitable value.

Other features to be considered are ventilation ducts, organ grills, alcoves and boxes, the shape of stage opening, etc. These are usually of small importance compared to the first three named.

Each auditorium presents its own particular problems, but the solution in each case should be based on these principles.

This paper has dealt only with the control of sounds which are generated in a room. This control is no longer a matter of chance. The results of theory and practice may be applied with confidence to any auditorium to obtain the best acoustic results. As an illustration, early in 1924 the writer was asked to visit a certain theatre in Connecticut to see if some remedy could be prescribed for faulty acoustics. On investigation, it was found that the acoustics were satisfactory for music, but unsatisfactory for speaking. The reverberation time was found to be 2.5 seconds, which was slightly more than the desired value. By calculation it was found that velvet hangings placed at the exits, along the rear of the auditorium and at the rear of the stage, would be sufficient to reduce the time to about 1.5 seconds. This recommendation was followed, with, as the theatre manager later stated, perfect results. This case was not difficult to treat; a higher reverberation time might have required more drastic methods.

The control of sounds entering a room from without, that is, the matter of sound insulation, is beyond the limit of this paper and may be treated at a later time.

[3] Acoustics of Buildings, by F. R. Watson.

Textile Chemistry: An Introduction to the Chemistry of the Cotton Industry. By F. J. Cooper. London: Methuen & Co., 1923. 235 pp.

This is a textbook intended to provide the necessary elementary chemical knowledge for textile students. Two-thirds of it is devoted to simple exercises in chemistry and the final third to the application of chemistry to textile manufacturing.

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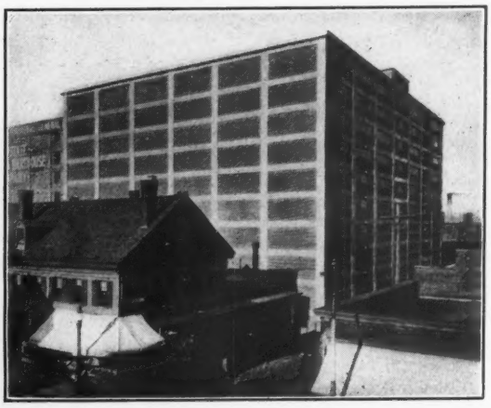

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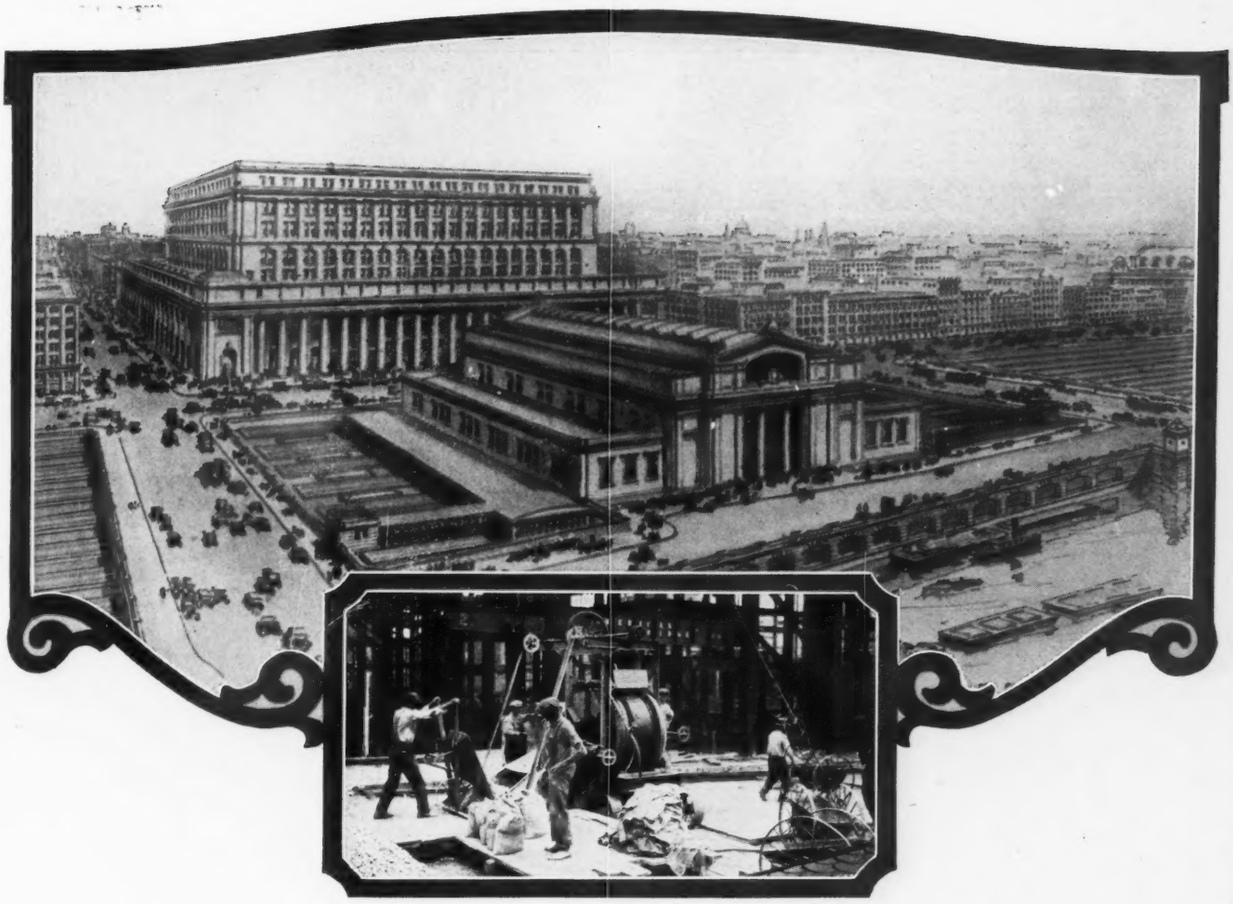

New Union Station, Chicago, and Koehring

THE new terminal of the Chicago, Milwaukee and St. Paul, Chicago, Burlington and Quincy, Chicago and Alton and Pennsylvania railroads now being completed, will be the finest railway station in the world. Covering two entire blocks, the value of the buildings alone is $15,000,000.

Caisson work, retaining walls, substructures; concrete arches, superstructure—the concrete work throughout on this Union Station is another product of Koehring Concrete Mixers.

Over 22,000 cubic yards of concrete were used in the 163 caissons, retaining walls and substructures; and approximately 25,000 cubic yards additional were required for the arches and superstructural work.

Koehring Mixers and Pavers are identified with the noteworthy building and road construction projects in all parts of the country.

"Concrete—Its Manufacture and Use", now in its fourth edition, is a 207 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.

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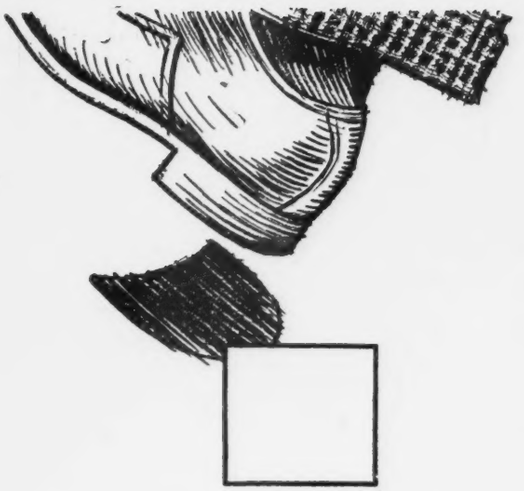

Footprints

Put a print of your sole alongside a print of your heel. Then you see part of the reason why soles wear longer than heels—why you must have your heels rebuilt twice or oftener, to every new pair of soles.

"Load area" is the technical explanation. Your heels have only about one-third the area of your soles. Your shuffles and weight are distributed over one-third less space. Hence the more rapid wear.

All this leads to Timken Bearings. The rectangle beside the sole print above shows the relative "load area" of a roller bearing as contrasted with bearings of other types (see square by heel print).

Put a bearing at the pinion gear of an automobile, or in the differential. Here the slightest effect of wear is to put the gears out of alignment—with deadly results.

But because of larger load area, wear in a Timken Bearing is so slow as to be unnoticeable during the life of the average car. And even if it should occur, a turn of a nut counteracts its effects. After thousands of miles, a Timken Bearing can be readily adjusted so that it's as good as new again. In which important characteristic, Timken Bearings are unlike *either* soles or heels!

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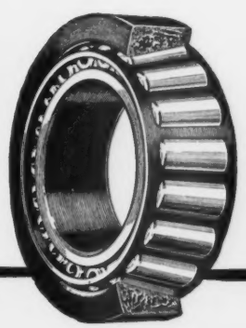

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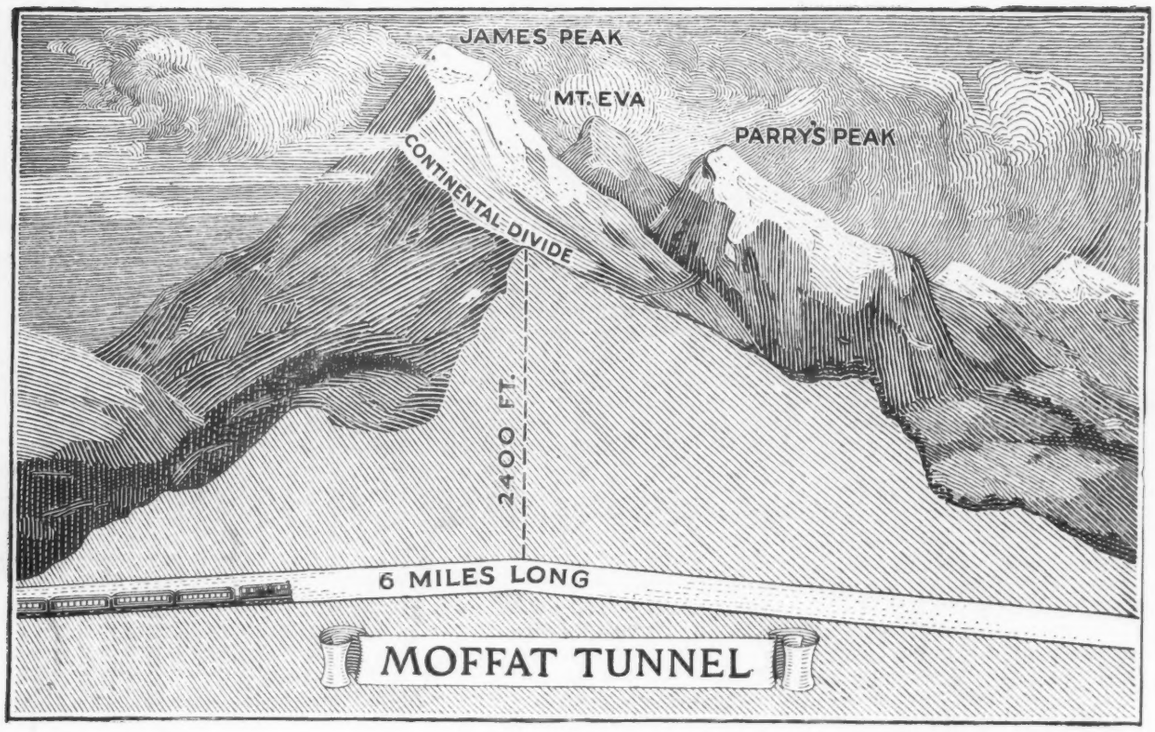

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